DOCUMENT RESUME

ED 114 281 SE 019 774

AUTHOR Abeles, Sigmund, Ed.; Shackleton, Robert W., Ed.
TITLE Science Educator's Guide.
INSTITUTION Connecticut State Dept. of Education, Hartford.
PUB DATE May 75
NOTE 188p.

EDRS PRICE MF-$0.76 HC-$9.51 Plus Postage
DESCRIPTORS *Administrator Guides; Curriculum; Elementary Education; Elementary School Science; *Instruction; Instructional Materials; *Science Education; *Science Programs; Secondary Education; Secondary School Science; *Teaching Guides
IDENTIFIERS *Connecticut

ABSTRACT

The purpose of this guide is to provide information about instructional techniques, course offerings, evaluation methods, and science budgets relating to science programs in Connecticut schools. The information in the report is divided into the following nine sections: a philosophy for the teaching of science, instructional patterns, science curriculum, program evaluation, school science facilities, science laboratory safety, supervision of science programs, preparing the science budget, and school time schedules. Each section presents the science teacher and administrator with suggestions and background information pertaining to each topic. Also included are the following appendices: a directory of publishers, film distributors, and scientific supply houses; safety recommendations and state safety laws; and a selected bibliography on science education. (MLH)

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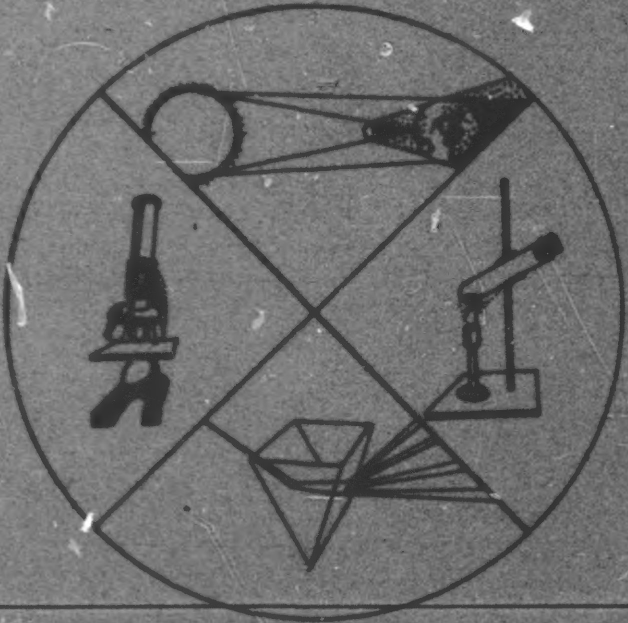

science educator's guide

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SCIENCE EDUCATOR'S GUIDE

EDITED BY

Dr. Sigmund Abeles
Science Consultant
Connecticut State Department of Education

Robert W. Shackleton
Chairman, Science Department
New Canaan High School

May, 1975

This document is based upon the written materials and critical comments of:

Sigmund Abeles

Science Consultant, Connecticut State Department of Education

Louis Coulomb

Chairman, Science Department, Startford Public Schools

Charles Deafenbaugh

Science Supervisor, New Haven Public Schools

Daniel Kavanaugh

Science Supervisor, Guilford Public Schools

Robert Lavenburg

Science Coordinator, Bloomfield Public Schools

Edward Rusczyk

Science Teacher, New Canaan High School

Robert W. Shackleton

Chairman, Science Department, New Canaan High School

Murray Stock

Science Coordinator, Greenwich Public Schools

Thomas E. Tinsley, Jr.

Director of Secondary Education, Shelton Public Schools

Charles Vasquez

Chairman, Science Department, Darien High School

FOREWORD

This guide was written at the suggestion of many science department chairmen and teachers in Connecticut schools.

A large number of changes in programming, instructional techniques, course offerings, methods of evaluation and even science budgeting have taken place over the past few years.

The purpose of this guide is to provide information about current procedures and practices in these areas so that administrators, supervisors and teachers may be made aware of the possible implications that these changes have for the science programs in their schools.

Science and technology play an important role in the economic and cultural life of Connecticut. Recent surveys on a national level show that science continues to be held in high esteem by the citizenry of the United States. These national surveys are echoed by a recent survey of Connecticut's secondary schools showing that enrollments in science programs continue to grow in the light of a relatively stable total enrollment.

Science is and will continue to be an important component of our culture. Our schools provide an important avenue for teaching youth about the content and processes of science as well as the opportunities which lie in this field. It is hoped that this guide will serve to widen this avenue by providing school personnel with some useful tools for improving their science programs.

This document is a preliminary draft.
Suggestions as to additions, modifications or deletions are welcome.
Please send them to:

Dr. Sigmund Abeles
State Dept. of Education
Hartford, Connecticut 06115

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A PHILOSOPHY FOR THE TEACHING OF SCIENCE

Introduction

The past, the present, and the future of our schools coexist. Today's ideas and practices have been inherited from the past and tomorrow's processes and ideals are being cultivated today. Ours is a complicated, rapidly changing technological world. And throughout the history of education, preparing youth for the constant adjustments associated with the changing social order has been the Herculean task bequeathed the school. An eminent sociologist has expertly described the role of the school in a changing society:

> Nothing is less practical than a practical education if the result is a trained incapacity for adaptation to change or continuous learning for some degree of creativity. The school will fulfill its function as an agency of developmental change only if it prepares its graduates for a somewhat uncertain world where no niche is absolutely secure and few niches even hold their shape well.
> (Wilbert Moore, 1967)

We are charged with the responsibility of preparing our young people for life. There is a set of assumptions which can be made about the nature of man. Man is rational, that is, man can see alternatives and choose among them. Further, within this frame of reference, rationality in man means that man does not act capriciously, whimsically, or without some justification which to him makes sense; man behaves with a reason. Even further, man can learn to increase his ability to act with reason, to improve through his own power his grounds for choosing. Man desires to improve, has the courage to improve, is curious and enthusiastic about things which have meaning for him. And finally, man is a social being, requiring direct and vicarious human contact and response for survival.

A Statement of Purpose

First, among all the goals for science teaching which now seems increasingly important and which lacks proper conceptualization, is that of science for the citizen. The matter can be looked at from many points of view. On the one hand, there is the extraordinary importance of science in public and national affairs. In a democracy in which the citizen is the ultimate determinant of action through his ballot, there is a dangerous gap developing between some of the most important affairs of state and the understanding of them by the citizen.

> These are hard times for the layman. He is thought no longer competent to work out his own opinions on many matters--even many that touch him intimately. His very survival has become the property of committees and subject of learned arguments among specialists. He has little to say, poor fish, being largely ignorant of the information upon which plans for him are based. (Weaver, 1960)

Obviously this can be applied to science--fluoridation of water; to fallout; to the role of chemical and biological agents in agriculture and in conservation; and to the control of food, drugs, and occupational and environmental hazards. But the matter goes beyond the practical point. It is also a question of the spirit and character of our age. This is an age of science. Education is supposed, among other things and perhaps most importantly, to orient the individual to the environment, in which he must live and work and find his enjoyments and satisfactions. Today, science and technology are the main components of that environment. Presently, the average citizen cannot be at home in that environment if he does not achieve some degree of rapport with it.

It is not necessary that he be a physicist, a chemist, or an electronics expert. But he should know the nature of science and something of how it works, have some feel for and understanding of how a scientist works and thinks, and eventually develop a decent respect for what science can do and what it cannot do. He need not know how to assess the exact reliability of a given scientific study of the dangers of water fluoridation, or its lack of danger. He should know that science can estimate them, however, and that the results can give practical guidelines for practice. He need not know how to examine the age of a fossil, but he should know that reliable scientists do know how and can be trusted. He should, in addition, have some insight into the relevant methodology.

Thus, our direction becomes clear. We need to be more concerned about the ways in which our young people are going to be different as a result of their science experiences in the curriculum which we build. They should attain not only a better comprehension of the conceptual schemes which scientists have developed in their efforts to explain natural phenomena but also a better understanding of how these concepts have affected the personal, social, economical, and political lives of people. They should develop not only a better understanding of the process of inquiry as used by the scientist but greater competence in using this process of inquiry, and consequently become more self-directive in their learning. Finally, they should become motivated in higher proportions than is currently the case, to sustain intellectual interests after their formal schooling is completed.

> We shall need a society which is sufficiently honest and open-minded to recognize its problems, sufficiently creative to conceive new solutions and sufficiently purposeful to put those new solutions into effect. It should be, in short, a self-renewing society ready to improvise solutions to problems it won't recognize until tomorrow. The vitality of our science and technology will have a good deal to do with whether we achieve that kind of society. (John Gardner)

Goals of Science Education

1. To develop a sense of humility--scientists constantly guard against the human tendency to be opinionated, dogmatic, and pedantic.

2. The science program should allow for successful achievement by children. Evidence continues to mount in support of the importance of success in development of the self-disciplined, confident, and achievement-oriented individual. This does not mean that children should be graded so that all succeed, since grades are arbitrary. We should be sure that materials and experiences available are such that students can successfully manipulate and investigate them.

3. To develop a positive approach to failure. . . failure is a type of success, "it says that at least it is not this particular answer."

4. To develop control of emotion. An attempt should be made to guard against decisions based on erroneous observations, misleading generalities, inadequate formulations, and unconscious prejudice. To know and understand one's own behavior and emotions is to control them; a self-awareness; to know realistic limitations.

5. To open the vistas of the cultural implications of science as a cause and effect relationship. It is not possible to discuss science outside of its relationship with human beings since science, both as a body of knowledge and as a process, is a product of human intellect.

6. To develop the thoughtful person who will be able to function in a state of doubt, hesitation, and perplexity, in order to

originate an act of searching, hunting, and inquiring, to find materials that will resolve the doubt and dispose of the perplexity by:

....the correct assessing of statements;
....the critical, reflective search for valid conclusions which solve our problems;
....the process of examining both concrete and verbal materials in light of related objective evidence, comparing the object or statement with some norm or standard, and concluding or acting upon the judgment then made;
....an approach to thought characterized by caution in drawing conclusions, based upon accurate and adequate evidence. One must be cognizant that the mind reflects superstition and authority, accepts cause and effect relationships, and recognizes that conclusions must be modified in the light of added evidence;
....to exercise a reasoned opinion involving careful judgment and to make correct assessments of statements;
....the ability to use and analyze logical statements and arguments;
....thinking that proceeds on the basis of careful evaluation of premises and evidence and comes to conclusions cautiously through the consideration of all pertinent factors;
....to recognize and capitalize on chance happenings.

To realize the above goals and objectives, we must offer students various opportunities to:

....recognize and define problems;
....clarify the problems by making appropriate definitions, distinguish between fact and assumptions, collect and organize relevant information;
....formulate possible explanations or solutions;
....select one or more promising hypotheses for testing and verification;
....initiate controlled experimentation to test hypotheses or ideas;
....state tentative conclusions based on data from testing.

The skill development necessary for the realization of the goals and objectives set forth herein should include:

1. Observations (including experimentation)
2. Analysis and synthesis
3. Imagination
4. Supposition and idealization
5. Inference (inductive and deductive)
6. Comparison (including analogy) at first glance
7. Construction of models

INSTRUCTIONAL PATTERNS

The instructional patterns examined in this section represent a technique or methodology of action rather than the text or program which utilizes this technique. The use of such techniques as individualized instruction, computer-assisted instruction, learning activity packages, and others should be considered not only from the standpoint of the classroom structure they produce but also from the philosophical basis from which they emerge. All patterns of instruction, traditional, teacher-centered, or student-centered, are representations of philosophical foundations based on fulfilling the diverse needs of students.

Traditional Patterns of Instruction

In comparison to many of the science programs in use in today's schools, the traditional patterns of instruction differ greatly. Science as taught in the "traditional" manner placed great emphasis on the teacher and his ability to get the material across to the student. Much time and effort were spent by the teacher in preparing lectures, class demonstrations, and laboratory exercises that would work or be finished in a specified length of time.

Content in the traditional courses was often presented as dogma and little attempt was made to entertain diverse views or the idea that science itself is often not fact but probabilistic. A single text was often utilized in an attempt to give students an overview of a complete discipline. Often the study of an individual topic was remembered by the student as a vocabulary lesson rather than an investigation of interrelated science concepts.

In this traditional approach, the doing of experiments and the teaching of science were considered to be one. However, the experiments, in order to fit into neat class periods and provide the correct answers, usually degenerated into little more than exercises designed to test the student's ability to follow a set of directions. The importance and difference between observations, data, and inferences were usually lost in the omnipresent quest for the right answer.

The drastic change in goals, content emphasis, and the availability of student materials since the early 1960s have caused great changes in the patterns in instruction found in our schools. The work of the curriculum committees sponsored by the National Science Foundation and commercial publishers have caused a change in science teaching on a broad front.

Emerging Patterns of Science Instruction

Modern courses in science were written for the most part by teams composed of working scientists and teachers, both actively involved in their respective fields. While each new program or text had an entirely different team, certain similar characteristics have become evident. The need to stress understanding of scientific inquiry, the importance of conceptual development, skills, and processes, and the emphasis on student activity have produced a science which is student-centered.

Modern science instructional patterns, with their emphasis on student inquiry, require that the student deal directly with the materials of science. The student is asked to make observations and try to arrange them to suggest possible solutions to significant questions of science. While this has been called the discovery approach, every student is not required to rediscover the wheel; rather, the ability to cope with new situations is the prime goal.

Most of the emerging patterns of science instruction emphasize the importance of laboratory experiences. However, the interpretation of the results, rather than the results themselves, are of paramount importance. A laboratory experiment is designed to give students a chance to manipulate a variety of materials and strategies and skills in order to solve or investigate an individual problem.

The emerging patterns of instruction in today's schools should not be considered static of terminal. They are part of an attempt to better educate the student in line with what has been discovered in the area of learning theory. The following section is an attempt to summarize briefly some of the teaching strategies in use today.

Patterns of Instruction

1. Audiotutorial--A method of instruction which primarily uses tapes, slides, transparencies, printed materials, and other audiovisual materials to teach a unit. The materials are designed for a specific topic and should be available to the student at any time during the school day or evenings to utilize on an individual basis. These materials may be a self-contained unit, a review of classroom activities, supplementary topics or activities, or advanced topics to be done by an individual student at his convenience.

The following is an example of two guide sheets from an audiotutorial unit on water pollution:

A SAMPLE AUDIOTUTORIAL UNIT ON WATER POLLUTION

Guide Sheet #1

Throughout history, man has been intrigued by water. . . it has been a source of recreation, relaxation and adventure. Water has been described in poetry, frozen on canvas and explored in countless books and journals. Historically, water seemed to be unaffected by the activity of man. . .

> Roll on, thou deep and dark blue ocean--roll!
> Ten thousand fleets sweep over thee in vain;
> Man marks the earth with ruin--his control
> Stops with the shore.
>
> Lord Byron

Times have changed. . . today man has proved his ability to pollute, dredge and otherwise alter the ocean and inland bodies of water. . . During this unit, you will be exposed to ways in which man and his institutions have affected the water of the world. . . !

More specifically, this A-T unit is designed to sensitize you to many of the problems of water pollution. In addition, an attempt will be made to make you an active participant in the war on pollution!

This unit will:

1. Discuss ownership of water resources.
2. Determine the major polluters in our region and your town or city.
3. Describe the major classes of pollutants that are found in our streams, rivers and lakes.
4. Outline the effects of the major pollutants upon animal and plant life in fresh and salt water.
5. Discuss the availability of fresh water for residential and commercial use.
6. Outline the flow of water in the water cycle.
7. Suggest ways in which you can become involved in cleaning up polluted waterways.
8. Recommend ways of obtaining and maintaining clean water supplies.

Guide Sheet #2

Cool, Clear Water!

The uses of water are as varied as the mind can imagine. On this sheet jot down as many specific uses as you can in each category--but spend exactly 90 seconds doing it. At the end of 90 seconds, count the total number of entries you have made and write that number in the score circle.

Direct "Man" Uses

1. Drinking
2.
3.
4.
5.
6.
7. Making coffee
8.
9.
10.
11.
12.
13.
14.
15.

Indirect "Man" Uses

1. Washing cars
2. Cooking
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.

Industrial Uses

1.
2.
3.
4.
5. Making paper
6.
7.
8.
9.
10. Panning for gold
11.
12.
13.
14. Airconditioning
15.

Fun Uses

1.
2.
3. Filling water beds
4.
5.
6.
7.

Miscellaneous Uses

1.
2.
3. Making mud pies
4.
5.
6.

Turn on the tape.

2. Contracts--A method whereby the student and teacher agree to a specific learning package. Most of the work is conducted on an individual basis by the student. This may be accomplished partly in the classroom, in the resource center, away from school visitations, or various combinations of the above. This recognizes that all students are different in their educational goals and methods of learning. The following example shows a method of grade contracting used in a seventh grade unit on Protests. The activities for the students have been outlined and given to each student. This serves to show the existence of different numbers and types of activities used to gain a particular grade. While many different techniques are used in teaching contracts, the resulting contract is always arrived at in an individual conference between the student and the teacher.

SAMPLE CONTRACT UNIT ON PROTISTS

Activities

1) Read pages 114-116 in Life and the Molecule.
2) Read pages 23-28 in Modern Biology.
3) View filmstrips FS 146 and 147.
4) Listen to tapes #3 and 6 (see teacher).
5) Make a labeled drawing of a single celled organism.
6) Answer question found on page 117 of Life and the Molecule.
7) Do experiment on page 215 of Life and the Molecule and write up your results.

Level 1 (Grade A)

The student will do all activities above with the following exceptions and modifications:

1) General background reading must be done in the text Modern Biology.
2) Activity #2 will be done at home.
3) A three-dimensional model is required instead of a drawing.
4) Post test grade must exceed 90%.

Level 2 (Grade B)

The student will do all activities above except as modified.

1) View filmstrip FS 146 and 147 and answer questions provided.
2) Activity #2 will be done in class.
3) A labeled drawing is required.
4) Answer questions 1, 3, 4, 7, 9, and 15 on page 64.

5) Post test grade must exceed 80%.

Level 3 (Grade C)

The student will use the tapes provided for activity 1.

1) Omit activities #2, 6.
2) Answer only questions 1 and 3 on page 64.
3) Post test grade must exceed 70%.

I hereby agree to the above conditions as set forth in conjunction with my teacher for the grade of ________, for the week of September 15-22.

Teacher's Signature____________________
Student's Signature____________________

3. Non-graded or Continuous Progress Approach--An approach that allows the student to proceed at his own pace to achieve predetermined goals. The student is graded on his own performance and not in competition with others. Activities for the individual student are not limited to his chronological grade level simply because he is in that particular grade. A student is taken from the point of achievement he has attained in a particular discipline (usually based on pretest data) and is allowed to progress as far as he can, utilizing materials applicable to his mode of learning. This program is of necessity completely individualized and emphasizes growth in the individual student.

Most non-graded or continuous progress programs are arranged to cover a span of three to four years of instruction. This is done to keep the teaching load to a manageable level. While this type of program can be used in the traditional self-contained classroom structure, it has been more heavily utilized within the concept of open space modes of instruction.

4. Programmed Instruction--A device to lead a student through a series of predetermined experiences which are designed to expose a single or multiple concepts. The program may use a multimedia presentation, and most often requires the student to have some facility in reading.

Good programmed instructional units provide many advantages to the student. The program never loses patience with the student or gets off the track in discussion. It gives immediate reinforcement when the student is correct and provides instant correction in private when the student is in error. The student masters the material at his own rate on an individual basis. Programmed units can also be used for enrichment, remediation, or advanced study in the same subject or topical area.

The following excerpt was used in a high school biology unit on the skeletal system.

SAMPLE OF PROGRAMMED INSTRUCTION IN BIOLOGY

1. The vertebrate skeleton may be divided into two general parts: an axial skeleton, consisting of the skull, vertebral column, ribs, and sternum; and an appendicular skeleton, consisting of the appendages and their girdles. The jaw would be part of the ________________ skeleton. A finger bone would be part of the __________ skeleton.	
2. In general, the skeletons of all vertebrates are quite similar due to evolutionary relationship. The vertebral column of the frog is a part of the _________________ skeleton. The vertebral column of the human is part of the___________ skeleton.	axial, appendicular
3. Bones have many protuberances, depressions and passageways. Various terms are used to describe these features. A smooth protuberance at the end of a bone which articulates with another bone is termed a condyle. A foramen is an opening in a bone for the passage of nerves and blood vessels. Other protuberances noted on a bone or a projecting part are termed processes. A condyle differs from a process in that the condyle ______________________________________.	axial, axial
4. Another term used in osteology is fossa. This can be defined as a depression. A fossa then is a dent in the bone but a __________________ is a hole in a bone.	Articulates with another bone.

5. Team Teaching--An organizational pattern within which the school can greatly improve the quality of its instructional pattern. Although there are many types of teams and many different patterns of instructions used under the name of team teaching, all generally give better results in the following areas: (1) utilization of staff expertise, (2) provision for large and small group instruction, (3) flexibility in scheduling, and (4) use of audiovisual material.

6. Alternate School Approach--An individual approach to scheduling which utilizes variations in time, content, site, and curriculum to meet the needs of individual students. Each student confers with his counselor and works out his program for the school year. In addition, a plan for a complete program of two or more years may be drawn up for each student to guide him in the following years. Often parents are also involved in the planning and generally must approve of the student's plan. Student interest and state requirements for graduation are considered in planning a student's program.

All age levels have been involved in the alternate school approach, although most students seem to fall into the high school age group. The credits towards graduation which are earned are far different from the standard Carnegie Unit. Students receive a diploma and may go on to further education if they desire.

An example of a student's program who is interested in law might look like the following:

English Composition
History of Law
Practice of Law (in conjunction with a practicing lawyer)
Science
Mathematics

7. Interdisciplinary Approach--An approach which attempts to cross subject matter lines in order to present a comprehensive picture of a particular topic. All subject matter teachers must plan together so that an integrated program is presented.

For example, in discussing pollution the English teacher may have her students writing letters to various public officials to gain information and to try to institute change. The math teacher would be using relevant pollution data to devise his math program while the science teacher would be doing a series of experiments determining the extent of pollution in a particular area. Meanwhile, the social studies teacher is dealing with social ramifications of pollution and what might happen if changes are made.

8. CAI (Computer Assisted Instruction)--A program which comprises any self-initiated activity utilizing mechanical or electronics devices by which a student may study any selected topic. Numerous programs are available from computer corporations in the field of

math, science, language arts, and other areas. In most cases, a student response to some stimulus results in immediate acknowledgment of the correctness of the response.

An example of such a program may be the Milliken Oil Drop Experiment. Instead of actually doing the experiment, the student uses the Milliken program and feeds data into the computer. The computer then simulates the experiment and gives the results. The student can now do the experiment as many times as he wishes in a short period of time.

Computer Assisted Instruction may be used at any grade level. However, it is more often used in the upper grades.

9. LAPS (Learning Activity Packages)--A program which consists of materials by which a student may study a single topic on an individual basis. The materials may include booklets, pamphlets, diagnostic tests, and other written materials. Making use of such devices as tapes, filmstrips, filmloops, study sheets in conjunction with the traditional use of texts, the child is able to proceed through the material at his own rate. Individual conferences are held only as the need arises.

LAPS used at the lower elementary level usually covers only a single concept such as density. Those used at the upper levels may cover an entire unit or course such as Weather or Ecology. The following example is a section taken from a LAP used in the study of the metric system in the eighth grade. Notice that only four objectives are included in this package.

SAMPLE LAP EXERCISE FOR EIGHTH GRADE

Objectives	Given a Metric Ruler the student will be able to compute the length, width, and area of his desk.
	Given the appropriate formula the student will be able to compute area and volume in the metric system.
	Given the appropriate conversion factors the student will be able to convert simple metric measurements into our system of measurements.
	Given a metric ruler the student will be able to measure with facility (90% accuracy to centimeter level) any object in the room.

Students

1) Obtain from the teacher a meter stick. Identify the following divisions on this stick. Draw the length of each on your paper.

   a) Millimeter
   b) Decimeter
   c) Centimeter

2) Answer on your paper the following questions:

   a) How many millimeters are there in a meter?
   b) How many centimeters are there in a meter?
   c) How many millimeters are there in a centimeter?
   d) How many centimeters are there in a decimeter?
   e) How many decimeters are there in a meter?
   f) How many millimeters are there in a meter?

* * * * * *

All of the patterns of instruction included in this chapter are designed to make better use of professional personnel and to individualize instruction. Numerous variations or titles for similar activities may be found in the schools today; the ideas developed here are merely indicative of what may be done to improve the instructional program through more efficient use of professionals to individualize instruction.

SCIENCE CURRICULUM

In recent years the science curriculum in the schools has been the focus of much controversy, and many innovative courses have been written for all levels of instruction. In these courses, the emphasis has been placed on the process of scientific inquiry and the development of concepts rather than the memorization of a body of facts which represent a discipline.

In general, the courses or programs which have been developed since the early 1960s fall into three broad categories:

1. Those courses or programs developed on a national level through the auspices and funding of the National Science Foundation or similar organizations. These programs generally featured authorship by teams, writing conferences, activities which were pretested on a large scale, and materials designed for "hands on" student use. Typical examples of these courses or programs are the so-called alphabet curricula such as SAPA, ESS, and BSCS. After extensive development, pilot testing, and evaluation, the materials produced were placed in the hands of commercial publishers for production and distribution.

2. Those courses or programs developed by commercial publishers. This category includes standard science texts and other materials which are the mainstay of science programs. Taking their lead from the alphabet curricula, many of these programs also feature student-centered inquiry and materials designed for student use.

3. In more recent times, perhaps because of the influence of relevancy, individualization, and evaluation, programs developed within a district or system have become popular. Many of these programs feature the use of many different texts and the merging of activities, units, or packages from existing programs. This type of program, although more difficult to initiate, often meets the needs of individual communities and students to a greater degree.

Importance of the New Programs

Experiences of the past twenty years have shown that students need an education in science which not only keeps them abreast of recent developments in this field but also allows them to cope with the ever-changing requirements of a dynamic society. Modern science courses have real meaning only to the extent that they allow the student to function better in his present and future environment, and are a true measure of the endeavors of science.

Modern science courses attempt to utilize materials which are appropriate to the child's developmental stage and include both process and content-oriented materials.

The Role of Science in the Elementary School

Science should be a vital part of the elementary school curriculum for every child. One lives in a society which is characterized by scientific and technological development. In a world where information is increasing at a rapid rate, it is important for people to learn how to process material, to become scientifically literate, to become more aware of the latest technological development and how it affects them, and to function effectively in a changing society.

Some of the skills that should be taught are observing, measuring, classifying, predicting, communicating, interpreting data, experimenting, controlling variables, and formulating hypotheses.

The following is an example of a lesson used to develop the skill of observation.

SAMPLE #1

Activity 2

Put three sets of two containers (plastic cups) on a table or on the floor in front of the class. Mark one of the containers of each set with a square and the other with a circle. Put about 100 ml of a sodium bicarbonate solution (2 grams of baking soda to 100 ml of water) in the container marked with the square, and 100 ml of citric acid solution (2 grams of citric acid crystals to 100 ml of water) in the container marked with the circle. Put small pieces of cloth dyed with Congo red near each set of containers.

Ask three children to come forward and dip the piece of cloth in the container marked with the circle. Ask them to tell you what happened. (The red cloth turned blue when it was dipped in the bowl marked with a circle.) Ask three more children to come forward and dip some of the blue-colored Congo-red cloth (see *Materials)* in the bowl marked with the square and tell you what happened. You might let other groups of three children transfer the cloth from the bowl marked with the circle to the bowl marked with a square, and tell what they observe. (The blue color changes to red.) (See Figure 1.)

(**Note**: The citric acid solution is harmless, but it may be irritating to cut or scratched hands. For this reason, ask the children to transfer the cloth from the "circle" bowl to the "square" bowl by lifting it with a paste stick.)

Continue the activity until all the children have had a chance to dip cloth in the solutions and tell you what they observed. You might extend this activity by coloring the citric acid solution with red vegetable coloring so that red cloth dipped in the red solution turns blue. Similarly, you could color the sodium bicarbonate solution with blue vegetable coloring.

SOURCE: "SCIENCE - A PROCESS APPROACH" GINN AND COMPANY

The following is an example of a lesson used to develop the skill of classifying.

SAMPLE #2

Grandma's Button Box

TEACHING SUGGESTIONS

Sorting by color. Distribute a tray and a handful of buttons to each child. Discuss with the class the properties of the buttons as well as their similarities and differences. Then suggest that the individual button collections be sorted by color. Children should choose their own methods and number of groups. For example, some may group all red buttons into one stack and all other colors into another. Some may sort each color into a different pile; others may even separate colors into shades. Accept all these choices as correct, and encourage individual pupils to describe their sorting procedures.

Sorting by other properties. After the previous discussion has been completed, ask the children to sort their buttons according to another property. The number of groups and the properties they use should again be left completely to the pupils. Offer suggestions only if a child seems very confused. Afterwards ask a few children to describe the methods they used and let others participate in the discussion. As your pupils exchange ideas they will probably ask for more opportunities to sort buttons.

Individualizing the use of buttons. Children may also group the buttons according to specified numbers of properties. Color might be one property, color and shape designate two properties, and so on. Ask children to tell you what properties they used for their groupings.

If a child has trouble sorting his button collection, try giving him only eight or ten selected buttons during another session. Allow the children access to the buttons during free class periods. This additional work will help them analyze and further diversify their sorting methods.

SOURCE: SCIENCE CURRICULUM IMPROVEMENT STUDY RAND MCNALLY AND COMPANY

Science teaching should be inquiry-oriented in order to allow children to discover scientific ideas and concepts in a meaningful context. In addition, a "hands on" approach can stimulate the child to pursue an activity in which he may not initially be interested. Many children learn abstract ideas and concepts much more easily if they can begin with a concrete situation and proceed to the abstract.

In the primary grades, science is an excellent tool to help develop a child's vocabulary and reading interests. For example, when one is teaching a unit on properties, the words used to describe the object can be used as a vocabulary list which can be gradually expanded as the sophistication of the description increases. There are many excellent science books written for the elementary child which will attract his interest and help increase his desire to read.

Mathematics should be integrated with science whenever possible. Many opportunities to integrate occur in the areas of measuring, using numbers, experimenting, etc. For example, when one is measuring the growth of plants over a given time period, graphing should be introduced as a tool to record the results.

The average amount of time spent on science will vary starting with approximately one hour per week in kindergarten and gradually increasing to approximately four hours per week in sixth grade. Actual time spent per week will vary widely depending upon the type of activity or unit involved. An example of a possible schedule follows.

Grade	Days per Week	Minutes per Day
K	3	20
1	3	20
2	3	30
3	3	35
4	4	40
5	5	45
6	5	50

A multi-text approach in elementary science is desirable. The texts should be used as reference books and supplemented with library books, filstrips, cassettes, film loops, etc. The textbook should be adapted to fit the curriculum.

Evaluation of a Science Program

Evaluation should be an integral part of the elementary science program. Children should be evaluated in a variety of ways. Paper and pencil texts, one means of evaluation, should be constructed using inquiry-type questions, not just traditional fact recall-type questions. Other ways to evaluate include interview observations, anecdotal records, and the use of behavioral objectives. If behavioral objectives are set up, then the evaluation must include the accomplishment of these objectives. Evaluation can be used to determine what activity the student should do next, and how the student is progressing through a series of activities, as well as to evaluate the teaching that has occurred.

National Science Programs for the Elementary School

There are several inquiry-oriented elementary science programs that have been developed or are being developed on a national level. Members of the committees developing these programs include scientists and educators from elementary school through college. The three major programs are discussed below.

Elementary Science Study (ESS)

National funding of science programs at the elementary level began with the ESS program in 1960. Over a period of several years, many different people were involved in designing and testing a number of separate units. Each unit is an entity and generally may be used successfully on two or more different grade levels. The ESS units emphasize phenomena with concepts and processes as byproducts.

In developing the units, various scientific activities were tried in the classroom. Careful records from teachers, students, and developers were kept and used to evaluate and revise the unit. The units were tested extensively with many students and teachers in a wide variety of situations across the country.

Units have been designed for grades K-9 in the subject areas of physical science, biological science, earth science, and general skills.

Some units are developed in detail and come equipped with a complete kit of materials. Other units are less fully developed and merely contain suggested activities around which a teacher might plan and develop a unit.

Along with the teacher's guides, kits of materials have been developed for approximately two-thirds of the units. In addition, some units utilize film loops, student worksheets, and activity cards.

The following is an example of an activity from an ESS unit on Batteries and Bulbs.

SAMPLE #3

Testing Pathways

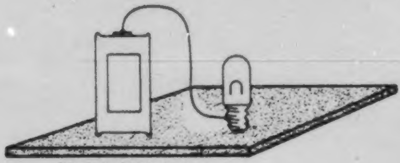
Before Starting to Teach

MATERIALS YOU WILL NEED

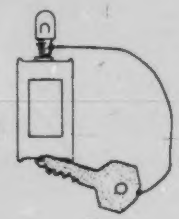
2 8-inch pieces of #22 plastic-covered copper wire
1 #48 (PB) bulb
1 #41 (WB) bulb
1 bulb holder
2 D batteries and holders
"junk box" items (see below)
1 milk carton (bottom half)
iodized salt
kosher salt
1 can of Comet cleanser
various liquids (water, cooking oil, vinegar, etc.)

You may already have made a pathway tester while working with Mystery Boxes. If not, refer to the diagram of a tester on page 38 to construct this device. The tester will enable you to discover which materials, when put in the pathway, will allow the bulb to light, and which will not.

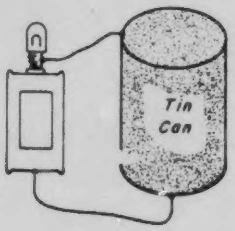
Test any material that is handy, such as paper clips, pencils, scissors, coins, paper, glass, your desk top. You can assemble a "junk box" of materials to test—things you have in the classroom or bring in from home. Make lists of things that will and will not allow the bulb to light. In general, what types of materials are in each list? Do you get the same results with the WB?

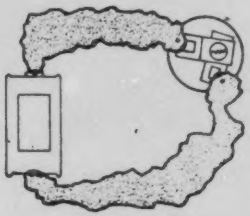


Metal desk top



Key





Aluminum foil

In the Classroom

MATERIALS YOU WILL NEED . . .

FOR EACH CHILD
containers (bottom half of milk cartons)

FOR THE CLASS
various wires
live and dead batteries
bulbs
"junk box" items that the children collect or bring in from home—keys, plastic pieces, bottles, paper clips, scissors, thread, toothpicks, aluminum foil, nails, etc.
1 can of Comet cleanser
1 box of iodized salt
1 box of baking soda
1 box of kosher salt
various liquids, such as milk, salt in water, water mixed with dirt, flour

LEAD-OFF QUESTIONS

What objects can you put in the pathway of the bulb that will allow the bulb to light?
What objects will not allow the bulb to light?

Children may have a number of different ways to try to put things into the circuit between battery and bulb. For a while, each of these arrangements will seem entirely new to them, and the fact that a common purpose underlies all such arrangements will not be obvious to them at first.

You can bring some order into the activity by raising questions that will support the purpose of the lead-off questions. The children can list materials on the chalkboard under the headings "Lights" and "Doesn't Light."

Some children may already have substituted several things for wire and will have a beginning list. Once children have investigated the electrical properties of some common objects, you can suggest testing some other things of special interest which they might not think of: aluminum foil, pipe cleaners, tin cans, various liquids.

They can make a class "junk box" or individual boxes of items they collect or bring in to test, swapping the items with their neighbors so that everyone will have a chance to try as many materials as possible.

Testing liquids will need some guidance from you. It can be very deceptive. With a single battery, no liquid seems to complete the path. When you add more batteries, a faint glow is seen in the PB. (With four batteries, a strong salt solution will allow a PB to light immediately in the test circuit.) If you wait awhile, the bulb gets brighter without your adding more batteries. At this point, if some of the batteries are removed, perhaps even all but one, the bulb will still glow. The Fahnestock clips are not essential on the ends of the wires in some of the liquids to be tested, but they are a help in others since they increase the surface area in contact with the liquid. Some liquids will, however, allow the bulb to light in a tester without Fahnestock clips.

Some children get discouraged when they try only one battery with liquids, and then confused when another is suggested. You can drop a hint by asking what happens to the brightness of a bulb when another battery is added to the circuit. If you could use enough batteries, maybe even wood, air, or plastic could constitute a successful pathway to a bulb!

ACTIVITIES CHILDREN MAY TRY

Put any one object in the path with a battery and bulb.
Put several objects together in the path.
Use both good and dead batteries in the path.
Make two or more lists of materials: those materials which complete the path to a bulb, those which do not complete the path to a bulb, and perhaps those which complete the path to a bulb only under special conditions.
Try various liquids in the path to a bulb to see if they make the bulb light.
Use parts of a household bulb as part of the path.
See which size of household bulb (7½ to 100-watt) will make a WB brightest, if the WB and household bulb are in the same path with a battery.
Vary the amount of salt (or other substances) in solution, the distance between the Fahnestock clips, or the type of bulb used, to see if these changes make any difference in the way the bulb lights.

POSSIBLE DISCUSSION QUESTIONS

The basis for this discussion is the lists of materials that will and will not complete a pathway to light a bulb.

How is it that certain materials appear on both lists?

Will a second battery complete the path? Does it have to be a live battery to do this?

How does the PB differ from the WB in a test of the same materials?

Does the bulb glow with the same brightness with each material that does complete the path?

What do you get when you test pencil lead, some of the silver-colored (Nichrome) wire, or the carbon rod from a battery? Does it matter how long the piece of wire or lead is?

Are there any changes in the Fahnestock clips when you are testing a liquid?

Optional Demonstration

MATERIALS YOU WILL NEED

2	4-inch pieces of #20 bare copper wire
1	#41 (WB) bulb and holder
1	D battery and holder
1	one-quart or larger size clear plastic or glass container

If your students worked with liquids in "Testing Pathways," you may want to do the following demonstration.

Fill the container with tap water. Have a WB connected in the path with a D battery.

LEAD-OFF QUESTION

What will happen to the lighted bulb when it is put into the water?

Some typical class comments might be:
"It will go out, because the water will short-circuit everything."
"It will get dimmer."
"The bulb will burn more brightly."
"Nothing will happen."
"The bulb will break. It will give off a flash as soon as it hits the water."

FOLLOW-UP QUESTIONS

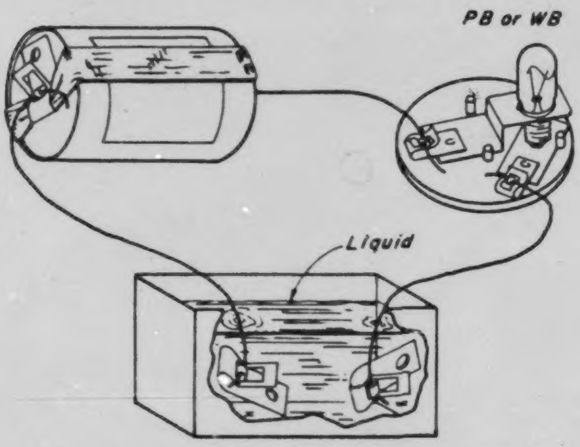
What can you add to the water to make the bulb go out?

Students who have worked with salt-water pathways will readily suggest adding salt. Others may suggest adding sugar, vinegar, or other substances. The bulb will, however, continue to light unchanged.

A whole series of questions can be raised at this point concerning the lifetime of the circuit in water and how it will compare with the lifetime of a similar circuit not in water. Will a circuit in a salt-water solution have the same lifetime as a circuit in tap water? How will other solutions affect the lifetime? You may want to allow your students to explore these and other similar questions more fully on their own.

Note: The students should again be reminded of the dangers of playing or experimenting with household current.

Now put two batteries in your testing circuit. With each bulb test some liquids, such as a strong solution of iodized salt or kosher salt or Comet cleanser in water. If the bulb doesn't light, try more than two batteries. The kosher salt solution is an interesting variation to try because the chemical reaction that takes place at the Fahnestock clips on the ends of the wires is different from the one with iodized salt. Comet is used because its reaction is different from that of other cleansers. Be sure the Fahnestock clips are not touching each other in the liquid. If they touch, you are testing the clips and not the liquid. Add the results of the liquid experiments to your list. In which list would you put water, oil, or vinegar?



SOURCE: "TESTING PATHWAYS" IS FROM THE ELEMENTARY SCIENCE STUDY UNIT BATTERIES AND BULBS PUBLISHED BY THE WEBSTER DIVISION OF MCGRAW-HILL BOOK COMPANY. REPRODUCED WITH THE PERMISSION OF THE EDUCATION DEVELOPMENT CENTER.

The following is a listing of ESS units by subject area.

General	Physical Science	Earth Science	Biological Sciences
Match & Measure	Light & Shadows	Daytime Astronomy	Growing Seeds
Primary Balancing	Mobiles		Life of Beans & Peas
Pattern Blocks	Spinning Tables	Rocks & Charts	Butterflies
Geoblocks	Mirror Cards	Where is the Moon	Eggs & Tadpoles
Tangrams	Sink or Float		Animals in the Classroom
Attribute Games & Problems	Clay Boats		Brine Shrimp
Musical Instrument Receipe Book	Drops, Streams, & Containers		Changes
	Mystery Powders		Pond Water
Printing			

[Cont.]

General	Physical Science	Earth Science	Biological Sciences
Structures	Ice Cubes		Starting from Seeds
Whistles & Strings	Colored Solutions		Mosquitoes
Peas & Particles	Batteries & Bulbs		Bones
Mapping	Optics		Small Things
	Pendulums		Tracks
	Stream Tables		Crayfish
	Senior Balancing		Budding Twigs
	Water Flow		Animal Activity
	Heating & Cooling		Earthworms
	Balloons & Gases		Microgardening
	Gases & "Airs"		Behavior of Mealworms
	Batteries & Bulbs II		
	Kitchen Physics		

The following is a possible sequence of ESS units.

K -- Light & Shadows, Growing Seeds, Butterflies
1 -- Pattern Blocks, Eggs & Tadpoles, Primary Balancing, Mobiles
2 -- Brine Shrimp, Changes, Structures, Spinning Tables
3 -- Clay Boats, Mystery Powders, Ice Cubes, Where is the Moon?
4 -- Mirror Cards, Tangrams, Rocks & Charts, Bones, Crayfish
5 -- Attribute Games, Small Things, Pond Water, Behavior of Mealworms, Peas & Particles
6 -- Batteries & Bulbs, Kitchen Physics, Mapping, Pendulums
7 -- Balloons & Gases, Microgardening, Heating & Cooling, Mosquitoes, Colored Solutions
8 -- Gases & "Airs," Senior Balancing, Stream Tables, Batteries & Bulbs II, Daytime Astronomy

Science A Process Approach (SAPA)

This highly structured program was developed under the auspices of the American Association for the Advancement of Science. It is a complete, integrated, and sequential program for grades K-6. As the title indicates, it is process skill-oriented and uses concepts and phenomena to teach these process skills. Behavioral objectives and competency measures are built-in to each exercise.

The thirteen process categories covered are observing, classifying, using space/time relationships, using numbers, communicating, measuring, predicting, inferring, formulating hypotheses, controlling variables, interpreting data, and defining operationally and experimenting. The child as an active participant learns to observe and predict by carrying out scientific tasks and furthermore discovers that science is not magic or a set of rigid rules, but a way of finding answers.

The following is an example of a measuring activity from SAPA.

SAMPLE #4

INSTRUCTIONAL PROCEDURE

Introduction

Give a child a spring and ask him what he can do with it. Invite other children to examine it and discover what they can do with it too. **What do you notice as you pull on the object?** (The harder the pull, the longer the stretch.) **What is this object called?** (A spring.) **Do you know of uses for springs?** Someone may suggest the spring scale. If not, do not introduce the idea at this time.

Now show the children two cylinders that are alike in size and appearance but have different weights. Ask the children to look at the cylinders but not to touch them, and to tell the ways they are alike (in size, color, texture, and shape). Next, have a child pick them up and tell if they differ in any way. (One is heavier than the other.) Ask the children whether they can think of a way to use the spring to tell something about the cylinder. Here again they may mention the spring scale.

Use *Activity 1* to review weight comparisons with an equal-arm balance. You can do this quickly if most of the children remember the technique—more thoroughly if it is new to many of them.

Activity 1

Review with the children their previous experiences with the equal-arm balance. You might set up a balance in front of the room on which you balance one object with another. Ask, **Is the downward force on each object greater than the force upward? Less? The same?** (The force on each side is the same, and the objects weigh the same.) **What is the cause of this force?** (The attraction of the earth for the object, or *earth-pull*.)

Pose the following questions about the cylinders used in the *Introduction*. The children should be able to answer these questions easily themselves from their previous experience.

How can you tell whether these two objects weigh about the same without using a balance? (By holding them.)

What will happen if you put the two objects on the opposite pans of the balance? (One pan will go down and the other up.)

Why? (The balance will be unbalanced because one object is pulled down with a greater force than the other.)

How can you find out how much more one object weighs than the other? (The children should suggest adding paper clips, washers, or some other units to the lighter object until the forces on both sides of the balance are equal.)

Divide the class into groups of four or five children. Give each group two cylinders that are alike in size and appearance, but have different weights. Then ask each group to use the equal-arm balance (one group at a time) to determine how much more one cylinder weighs than the other. Ask how they might express this difference. (One cylinder weighs ten paper clips more than the other.)

Hold up the spring again, and refer to their earlier suggestions about the usefulness of springs. Ask the children to think about how springs could be useful in comparing the earth-pull on the cylinders.

SOURCE: SCIENCE - A PROCESS APPROACH GINN AND COMPANY

Complete teacher guides, kits of materials, and student worksheets have been developed for the program.

Science Curriculum Improvement Study (SCIS)

The SCIS program is moderately structured, sequential, and consists of twelve units for grades 1-6. Major emphasis is placed on concepts and phenomena with process as a byproduct. SCIS provides for three stages in the learning cycle: exploration, invention, and discovery. "Exploration lessons give the children a variety of experiences with materials and equipment; invention lessons introduce new ideas that help children derive some meaning from their exploratory experiences; and children learn applications of these ideas in discovery lessons."

One biological science unit and one physical science unit are taught each year. Interaction, a major physical science theme, is developed using the concepts of matter and energy, while the concepts of organism and ecosystem are used to develop the organism-environment relationship in the life science units.

Behavioral objectives are not emphasized, but several objectives are written for each part of each unit. An example of one objective from the Material Objects unit is "to describe objects by their properties." The activity associated with this objective follows on the next page (see Sample #5).

Teachers' guides, student booklets, kits of materials, films, and film loops have been developed for the program. The twelve units are:

Physical Science	Life Science
Material Objects	Organisms
Interaction & Systems	Life Cycles
Subsystems & Variables	Populations
Relative Position & Motion	Environments
Energy Sources	Communities
Models: Electric & Magnetic Interaction	Ecoystems

Individual Science (IS)

The Individualized Science program, while considered primarily an elementary level offering, does extend its coverage to grade eight. This program, consisting of ten developmental levels developed by the University of Pittsburgh, is a multi-media approach to individualizing the science program. Each level consists of three or more units named after famous scientists. For example, the unit on observing is named Galileo. Within each unit there are placement tests, individual taped lessons, directed group activities, student activities, men and ideas filmstrip, directed readings in science, and science learning games.

SAMPLE #5

Grouping Collections of Objects

ADVANCE PREPARATION

Remove the drawer of wood, metal and plastic pieces from the kit. Mix the contents on two or three trays so various kinds of materials are on each one. Place the filled trays around the room so the children may conveniently take objects from them. Distribute a cardboard tray and a magnifier to each child.

TEACHING SUGGESTIONS

Introduction. In this first informal experience with the idea of material, the children deal with assortments of metal, plastic, and wood objects of the same shape and dimensions. Because these objects are of uniform size and shape, the children's attention is focused on other properties. The differences between such objects can be expressed by comparing color, markings, texture, or weight; the sorting which takes place will be based on properties such as these.

Each child places five to seven objects from one of the trays on his cardboard tray and uses his magnifier to observe them. After studying the objects, the children discuss their properties.

Sorting the objects. In this activity the children sort their objects. Offer no suggestions as to how this sorting should be done, but note how the children carry it out. Are the objects grouped only by color or by smoothness, for example? How many children divide their objects into wood, plastic, and metal groups? Do any sort by individual kinds of materials such as pine or walnut? Let the children discuss their sorting methods. Then allow them time to sort their collections differently.

Encouraging child-to-child discussions. Some children may wish to pool their objects to obtain a greater variety. Encourage them to compare and discuss the properties of the pieces and to sort them in several different ways. Use this activity as an opportunity to discover students' preconceptions about the composition of various materials. Are they, for example, sensitive to the differences between brass and aluminum, or do they only notice that these are both shiny or both metals?

Once some children have sorted their collections, let others try to decide how the groupings were carried out. Encourage the sorters to discuss the reasons for their decisions.

Even though you may not have introduced the concept of material, you can emphasize by direct example the distinction between a class of materials, such as "metal," and a specific kind of material, such as "aluminum." The children will have many more experiences to help them understand and use this idea.

When this chapter is completed, the children should put the wood pieces on several trays and the metal pieces on others. Return all the plastic pieces to the kit. Now the metal and wood pieces will be ready for use in Chapter 8.

SOURCE: SCIENCE CURRICULUM IMPROVEMENT STUDY RAND MCNALLY AND COMPANY

Each lesson in the program is complete, that is, it is a prepackaged kit that includes most of the materials necessary for completion of that concept. Tapes or written materials of each lesson are available and most lessons can be completed in one class period.

An example of a lesson from the Simpson Unit follows on the next page (see Sample #6).

Textbook Series

Most elementary science textbook series currently published are inquiry-oriented. Included in some teacher editions are the concepts to be covered and behavioral objectives for each concept. The texts generally cover a wide variety of topics including the physical, biological, and earth sciences. Some of the specific areas covered are weather, sound, rocks and minerals, animals, properties of objects, sets, machines, forces, electricity and magnetism, time, matter, measurement, heat and temperature, liquids and gases, air, light, energy, the human body, oceanography, the solar system, growth, and environment. The specific areas are often covered at all grade levels. No particular topic sequence is observed. Many programs include equipment and supply kits which can be purchased from the publisher. Some publishers provide consultants to conduct in-service sessions for the teachers at no cost to the school system. In selecting a textbook program, special attention should be paid to the total number of activities, the number that are teacher demonstrations, the number that children can do, and the number of activities that are inquiry-oriented.

* * *

The above section attempts to describe some of the new programs and their approaches. It should be remembered that new programs are continually being introduced and/or revised. Therefore, when selecting a program for a school system, science offerings should be carefully surveyed to ascertain what is currently available.

Middle School and Junior High Science

The middle and junior high schools have traditionally taken many different forms and usually included some combination of grades 5 through 9. While experience has shown that there is a distinctive need for this age-grade grouping, the middle or junior high school is often thought of in terms of a "capstone for elementary or stepping stone to high school" (Hurd, 1960). To have a truly effective program it can be neither of these, but must stand on its own merit.

As in the elementary school, science at this level should be considered in terms of the total educational experience of the student. The goals and purposes of this level should be clear.

Within the framework of the total school experience, science at this

SAMPLE #6

Simpson Lesson 3

Approximate working time: 30 minutes

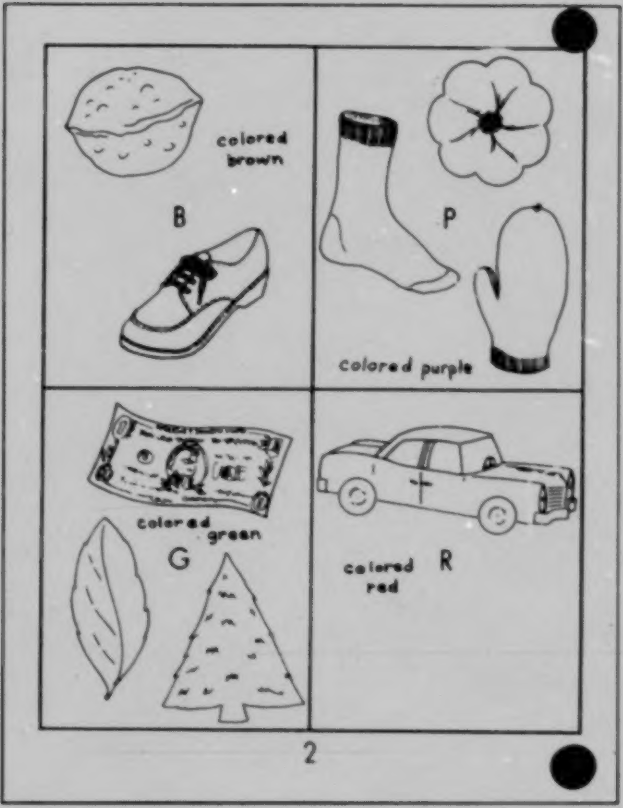
Materials needed: tape, booklet, kit, crayons, paste
from Central Supply: scissors

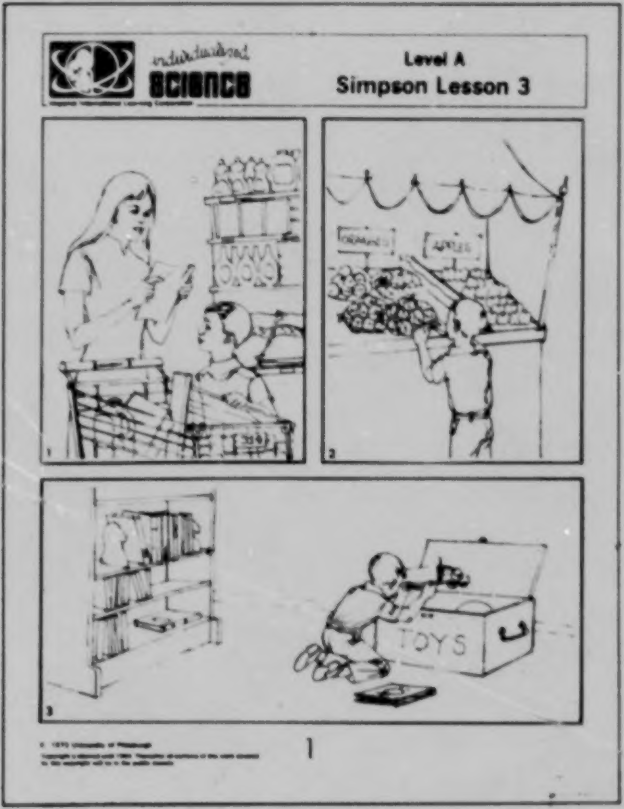
Terms introduced: sorting, sets

Summary

The student sorts the objects in the kit into sets on the basis of color. On page 3 of his booklet, he colors pictures of the following objects: flower, mitten, and sock (purple); car (red); leaf, tree, and dollar (green); and the nut and shoe (brown). After coloring the objects, the student cuts them out, sorts them into sets by color, and pastes them in the appropriate boxes on page 2.

NOTE: You should check the student's booklet to determine whether he has colored and sorted the objects properly.




individualized SCIENCE

Level A
Simpson Lesson 3

Source: Individualized Science
Imperial International Learning
Corporation

level should contribute primarily to the development of concepts. The processes of science, which include the development of necessary skills, both physical and intellectual, make it possible for the student to inquire into his environment. A valid relationship between science and other academic disciplines should be maintained. The development of student self-awareness and an understanding of his place in our society should be part of the curriculum at this level.

The effective learning environment in science is influenced by the physical arrangement of the building and the competence of the staff. The "new" science curriculum for middle or junior high schools requires teachers with an interest and background in the area of science. The basic background needed by the teacher is not only a function of college credits but also an understanding of and the ability to work with the existing goals and objectives of these programs.

The following descriptions represent a selection of programs presently available for the middle and junior high schools.

Intermediate Science Curriculum Study (ISCS)

The ISCS materials were originally developed at Florida State University. The main purpose of ISCS is to develop scientific literacy. The program's curriculum structure is two-dimensional. One part is a series of instructional materials designed to give the pupil practice in using intellectual skills important in the scientific process. The second part consists of materials designed to foster the attainment of selected basic concepts of science and to build these into higher order principles and generalizations.

General themes are developed over a three-year period. This longer time span permits a wide range of experiences leading to a greater understanding of each concept. In grade seven the pupil is made aware of process skills and is given practice in their use in grades 8 and 9. As he becomes more proficient, he is expected to use them freely in less contrived problem-centered situations. The basic content theme in grades 7 and 8 is entirely physical science because "a majority of students will not take courses in Physics and Chemistry at the high school level" (Florida State University, 1966).

Through the use of comprehensive diagrams, explicit directions, and the cartoon character "Iggy," the student is led through a highly structured series of experiences designed to teach a specific concept.

A typical ISCS exercise follows.

SAMPLE #7

8 Take It With a Grain of Salt

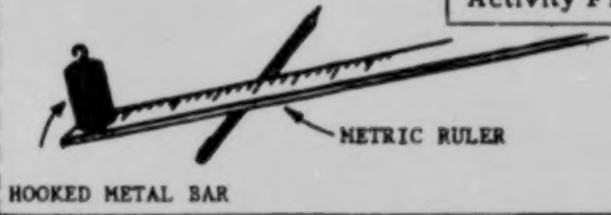
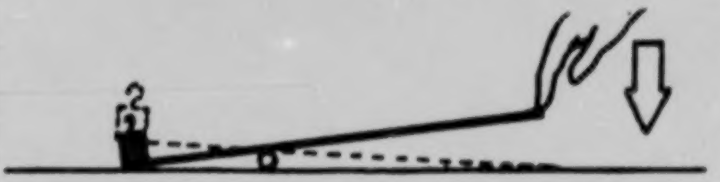
Seymour, a young man from Jerusalem, claimed he had set a world record for floating on water. He had practiced floating for years at a beach on the Dead Sea near his home. Finally, he took several witnesses with him to the Dead Sea, and they testified that he had floated for three days without moving his arms or legs.

PARIS TIMES
SEYMOUR SANK IN THE SEINE!
RESCUED BY CHILDREN

Seymour decided to demonstrate his ability to float in other parts of the world. His first stop was Paris, France where he planned to float in the Seine River. A large crowd gathered. He jumped into the water, and floated -- for two-and-one-half seconds. A very embarrassed Seymour headed quietly back to Jerusalem and was never heard from again.

Seymour found out that the Dead Sea and the Seine River are two quite different places. It's also possible that lifting things with inclined planes and pulleys is not the same as lifting them in other ways. Before you conclude that multiplying force times distance is always a good way to measure work, it would be well to take a look at a few more lifting situations.

You should already have a pencil. If you will pick up a metric ruler and a hooked metal bar from the supply area, you'll be ready to go.

Place the hooked metal bar on one end of a ruler. Slide a pencil under the ruler, close to the bar.	**Activity Frame 8-1** 
Push down on the high end of the ruler. Note how much force it takes to lift the bar completely off the desk.	**Activity Frame 8-2** 

Now pick up the hooked metal bar with your hard.

● 8-1. Which takes less force, lifting the bar directly or using the ruler? ______________________________

Let's take a closer look at what you have just done. Figure 8-1 shows the forces and distances involved.

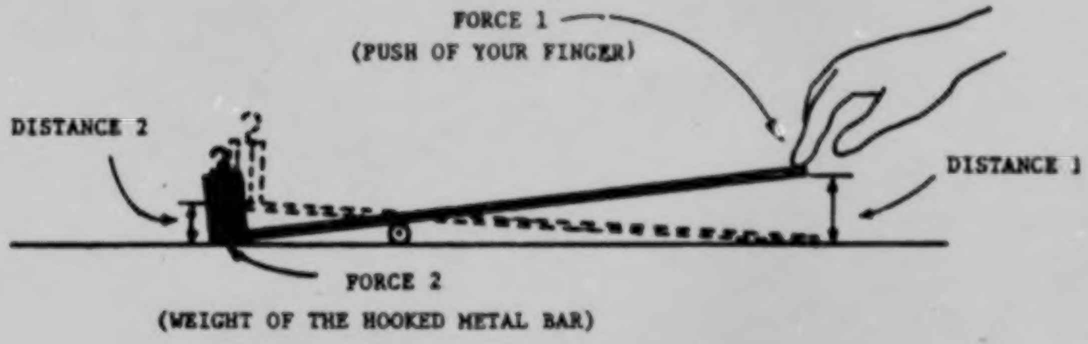


Figure 8-1

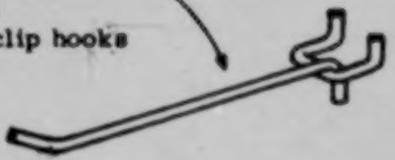
From your experiments with the inclined plane and the pulley, you should be able to predict how FORCE 1 times DISTANCE 1 would compare with FORCE 2 times DISTANCE 2.

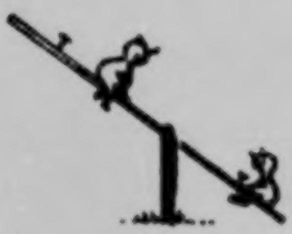
● 8-2. What is your prediction? ______________________________

____

To check your prediction, you need to make some force and distance measurements. But doing this would not be easy using the ruler-pencil set-up. You can help yourself to make better measurements by using a different apparatus to tackle the same problem. It's called an "equal-arm balance." You will need a partner and the following equipment:

1 pegboard stand
1 balance rod
1 metal pivot
3 clips for rod
2 sinkers
4 paper-clip hooks





SOURCE: THE FLORIDA STATE UNIVERSITY, PROBING THE NATURAL WORLD, VOLUME 1, FALL 1969 EXPERIMENTAL EDITION. COPYRIGHT ©1968 BY ERNEST BURKMAN, DIRECTOR INTERMEDIATE SCIENCE CURRICULUM STUDY. USED BY PERMISSION OF SILVER BURDETTE/ GENERAL LEARNING CORPORATION.

Introductory Physical Science Program (IPS)

IPS was developed by the Educational Services Incorporated (now Educational Development Corporation) for the junior high level. The two main purposes of IPS are (1) an orientation to physical science as a general education course and (2) a foundation for the "new" science courses at the senior high level.

The essential theme of IPS is the development of evidence for an atomic model of matter. The course content is selected and arranged to build a concept and then use the model to predict ideas about such things as heat and molecular motion. The authors believe that inquiry skills and the meaning of science are more adequately achieved through in-depth study of a major concept than by shallower treatment of a variety of topics.

The following selection from the program, while admittedly taken out of context, is used to show the use of experimentation in the building of concepts and the in-depth nature of the technique used.

SAMPLE #8

The Mass of Mixed Solutions

In the two experiments you have just done, a solid was either dissolved or melted. Now let us ask what happens to the mass when a solid is formed by mixing two liquids.

Pour lead nitrate solution into a small bottle until it is about one-third full. Now pour the same volume of sodium iodide into another bottle of the same size. Find the total mass of the bottles of solution and their caps. Now pour one solution into the same bottle with the other, and cap both bottles. Again find the total mass of both bottles. Did the mass change as a result of the mixing?

This results in a wide variety of techniques being used to examine the area. Each of the techniques invented is correct.

Interaction Series (IMB, IME, IET)

The Interaction Series is an example of the commercially developed program. This program was developed by Rand McNally and pretested in two trial editions in many parts of the country. The final program utilizes a student-centered, activity-oriented approach. The original design for Interaction Series was outlined in 1959 by a group of junior high teachers. As the major curriculum studies in science emerged, the material provided by these teachers was gradually changed so that the goals and philosophy of the Interaction Series more closely reflected those of BSCS, CHEM, and CBA programs.

The suggested grade seven program, Interaction: Man and the Biosphere, is an activity-oriented approach to the subject of life science. This is followed in grade eight by Interaction: Earth and Time, an earth science program designed to give the students a chance to investigate the area of earth science at their own level. The final level of this program, grade nine, Interaction: Matter and Energy, covers the area of physical science. The content areas of this program represent the three most commonly used courses at this level and are designed to give the student an introduction to these areas in preparation for their future choices at the high school level. The sequence given above may be varied depending upon the needs or wishes of a particular school system.

It should be recognized that the above courses are just a few of the many available at the middle and junior high school levels. They were selected because of their national exposure and their approach to student involvement.

High School Science

The teaching of science as independent subjects such as biology, chemistry, and physics has been traditional at the high school level. From its beginnings as an academic preparation for further study, through the emphasis on training for careers in technology in the 1960s, to its present-day status, the teaching of science has undergone a multitude of directional changes.

Science in today's high schools must undertake the fulfillment of many diverse goals. The skills and involvement developed at the lower levels must be carried to completion for those students not seriously interested in science as a career. The goal of the scientifically literate society is as relevant today as it was in the early 1950s. Course offerings in career development, both terminal and preparatory, are also included in today's comprehensive high school. General offerings in preparation for further academic pursuit, as well as specific science courses for students of high interest or ability, should be offered to meet the needs of a diverse student population.

The following section provides a brief description and examples from selected programs available at this level.

Biological Science Curriculum Study (BSCS)

Three versions of BSCS biology programs are presently available for use at the high school level. A wide range of supporting materials and teacher aids are also available. Each course is designed around a common set of conceptual themes. The first seven of these themes represent the major conceptual structure of biology and the last two, its inquiry phase. These themes are:

1. The history of biological concepts
2. Complementarity of structure and function
3. Diversity of type and unity of pattern
4. Change of organisms through time as evolution
5. Genetic continuity
6. The complementarity of the organism and its environment
7. Regulation and homeostasis
8. The biological basis of behavior
9. Science as investigation and inquiry

Three biology texts are available and are written to conform to the conceptual themes of the program. The first, *Biological Science: Molecules to Man*, examines the field of biology from the molecular point of view. The second, *High School Biology*, emphasizes an ecological approach. The third, *Biological Science/An Inquiry into Life*, more closely resembles a traditional textual treatment but places emphasis on the cellular and molecular phases of biology. Additional textual material for advanced and slower learners are also available.

BSCS Patterns and Processes

Another part of the BSCS publications is the Patterns and Processes Program. This program was written to fill a need discovered when the three other versions of BSCS were evaluated. Although the three main versions of BSCS were designed to reach all students, it was found that for a variety of reasons this was not the case. For those students who could not succeed in Yellow, Green, or Blue, a fourth program, the Red, based on the assumption that all students *can* learn important biological concepts, was developed.

The materials for this new program were written under the following guidelines:

1. It was an experimental program.
2. It would be a laboratory-oriented program.
3. Discussion was an important part of the program.
4. The reading material in the program would require the teachers' special attention.
5. Programmed instruction would be included as part of the regular instructional sequence.
6. Homework would contribute to the course.
7. Evaluation techniques should be many and varied.

The basic format of the course takes each topic to be investigated, and develops a series of ideas within the framework of this topic. Rather than presenting the ideas to the student, he develops and discovers them through the activities within the program.

The Biological Science Curriculum Study Committee has produced and is continuing to produce a number of courses and programs in the biological and life science areas.

The courses described above are but a portion of the total effort of this group. Some other programs such as "Me Now," "Me and My Environment," and a developing elementary science sequence represent other activities.

Chemical Education Materials Study (CHEM)

The CHEM Study materials were designed to help students understand facts about chemistry, where these facts come from, and what they mean. This basic goal is the result of the writing committees' feeling that too many chemistry courses were being conducted from the standpoint of factual memorization. In this program, facts are not considered as discrete bits of information but rather from the viewpoint of their contribution to man's insight into his natural environment.

The laboratory program for CHEM is based on the idea that experiments are designed to be open-ended in terms of results and interpretations. Experiments are introduced logically and sequentially in the course of the text narrative. The directions carefully guide the students through the laboratory activity. Emphasis is maintained on their problem-solving ability. Models are sometimes suggested by the laboratory experiences. In addition, the student learns to formulate models which may need to be modified or discarded as new information is acquired. The labwork is designed to provide observations and raise questions which serve as the basis for class discussions.

Physical Science Study Committee (PSSC)

The PSSC course is a step by step sequence of related concepts directed toward familiarizing the student with the two central themes in modern-day physics: the wave particle duality (elementary quantum physics) and the modern concept of the atom (elementary atomic physics). The main points are not crystallized until near the end of the course and almost the entire sequence is needed to build the understanding of these concepts. Laboratory materials are designed for "hands on" student use and are closely coordinated to the two central themes of the program. A useful series of films, loops and study guides are also available.

Earth Science Curriculum Project (ESCP)

The ESCP materials were developed under the auspices of the American Geological Institute as a grade nine earth science course. It is being used, however, at other grade levels. The text is divided into four main parts which give a broad overview of the area of earth science. These are meteorology, astronomy, geology, and oceanology.

Laboratory exercises are an integral part of the textbook and are intended to involve the student as an active inquirer. Many of the laboratory exercies give the student the opportunity to utilize mathematical skills.

Project Physics (PP)

Project Physics is designed to relate scientific activities within a social and cultural setting which will provide a comprehensive view to the workings of nature. An intensive view of physics through the medium of history and philosophy is provided.

The course is intended to serve a wide range of student interest and at the same time meet the requirements of a general education in physics. The subject matter of the course is built around six major related topics from motion to the introduction of atomic and nuclear models of matter. There is a persistent story line which runs through the entire course illustrating the unifying themes of physics. Through the use of self-instructional materials, multimedia aids, and laboratory activities, the program provides many alternatives which students may use to explore their interest in the field of physics.

Ideas and Investigations in Science (IIS)

The IIS program tries to convey the attitude that science is not an encyclopedic collection of facts or a neatly separable set of processes, but a mixture of information and activity. The program places equal emphasis on content and process in its coverage of ten great ideas or conceptual schemes in science.

IIS consists of two full-year courses: Biology and Physical Science. Although the courses complement each other, each is designed to function independently. Each new concept is built upon the initial one. The students' discovery activity is carefully guided by the teacher who makes them think about what they are doing and offers frequent encouragement and reinforcement. Student materials are easily readable, utilizing many graphic illustrations as well as containing the necessary directions and worksheets to guide the student through each investigation. The following excerpt from the program will serve to illustrate the format used to aid the students in their investigations. (see Sample #9 on the following two pages).

Engineering Concepts Curriculum Project (ECCP)

The Man Made World gives both science and nonscience students an understanding of technical concepts. Students look inside technology today, studying information systems, communication with machines modeling, decision making, computer operations, etc. As the students learn to ask the right questions about science and technology, they also develop the skills to relate technology to their own experiences.

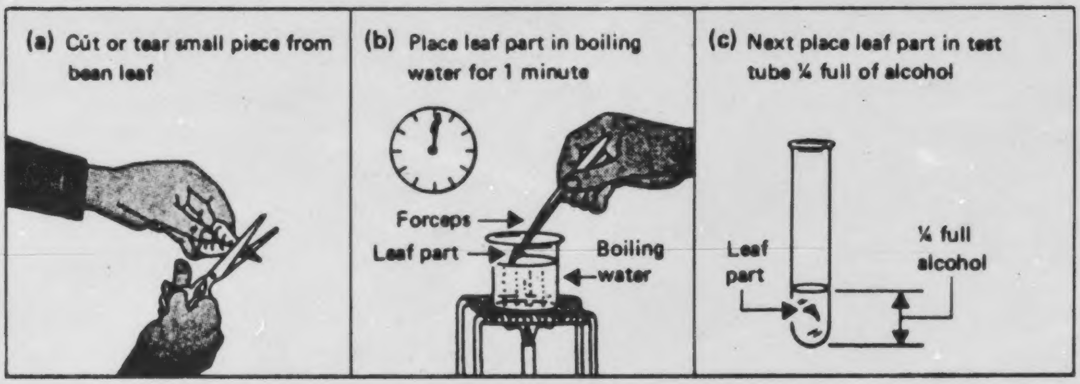
Students use a systematic approach to participate in many current problems of today's society. Such problems as pollution control, waste disposal, food, health care, and urban housing are covered in a humanistic manner.

SAMPLE #9

B. THE JOLLY GREEN BEAN

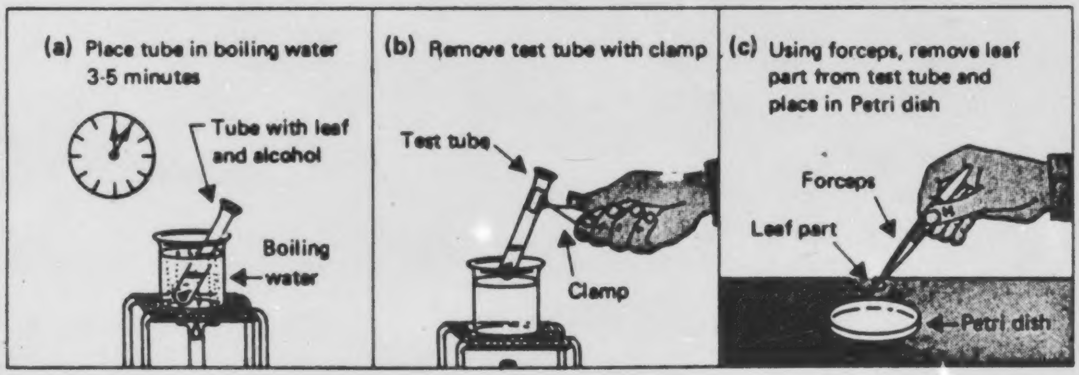
You will be shown a 3-4 week old bean plant. The plant has been given only water and sunlight. We will call this untreated plant our control.

Cut a small piece from one of the bean leaves. Using forceps, place your leaf part in a beaker of boiling water for one minute. Transfer the leaf part to a test tube ¼ full of methyl or ethyl alcohol. Place the test tube in a beaker of boiling water.

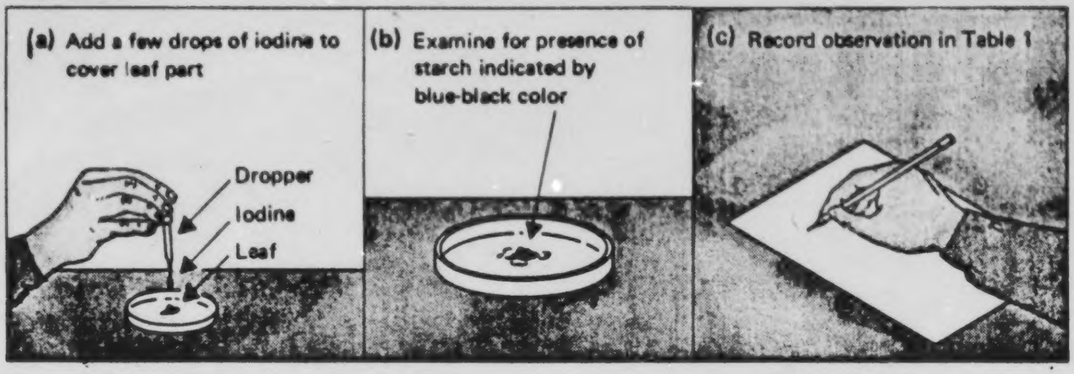

(a) Cut or tear small piece from bean leaf
(b) Place leaf part in boiling water for 1 minute
Forceps
Leaf part
Boiling water
(c) Next place leaf part in test tube ¼ full of alcohol
Leaf part
¼ full alcohol

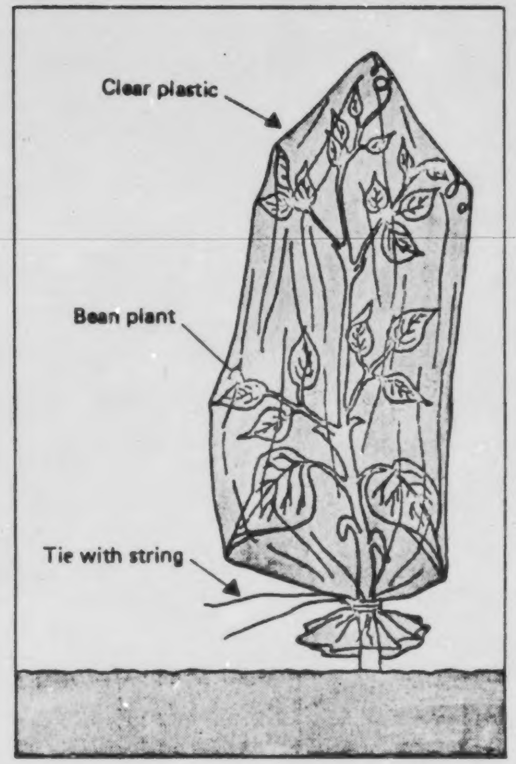
CAUTION: DO NOT HEAT THE ALCOHOL DIRECTLY.

The alcohol will take the green color out of the leaf part in 3-5 minutes. When the leaf part is no longer green, remove the test tube from the boiling water. Use forceps to place the leaf part in a Petri dish.


(a) Place tube in boiling water 3-5 minutes
Tube with leaf and alcohol
Boiling water
(b) Remove test tube with clamp
Test tube
Clamp
(c) Using forceps, remove leaf part from test tube and place in Petri dish
Forceps
Leaf part
Petri dish

Add a few drops of iodine solution to cover the leaf part. Iodine is used to test for starch. A blue-black color indicates the presence of starch. Does your control leaf show a positive test for starch? Record your observation in Table 1 of your data sheet.


(a) Add a few drops of iodine to cover leaf part
Dropper
Iodine
Leaf
(b) Examine for presence of starch indicated by blue-black color
(c) Record observation in Table 1


Clear plastic
Bean plant
Tie with string

C. THE NOT-SO-JOLLY GREEN BEAN

Your teacher will show you another bean plant. The leaves on this plant have been smeared with petroleum jelly or covered with a plastic wrap.

2. What do you predict the petroleum jelly or plastic wrap will prevent from entering the leaves?

Cut a small piece from one of the leaves on this bean plant. Gently remove the petroleum jelly or the plastic wrap. Repeat the procedure in part B with this piece of leaf. Record the result of your test in Table 1.

D. WHO'S JOLLY NOW?

Your teacher will show you still another bean plant. This plant has been in the dark for 3-5 days.

3. Predict the result of a starch test on this plant.

SOURCE: FROM IDEAS AND INVESTIGATIONS IN SCIENCE. BIOLOGY
IDEA 5: ECOLOGY BY HARRY K. WONG AND MALVIN S.
DOLMATY ©1971 BY PRENTICE-HALL, INC., ENGLEWOOD
CLIFFS, N.J. REPRINTED BY PERMISSION.

The program was originally suggested for only advanced levels, but is currently finding use in some junior high schools.

The laboratory exercises are designed to simulate the real problems that an engineer might encounter in his work. Laboratory material is available and emphasizes a practical, problem-solving approach to realistic problems.

For an example of the format used in the student laboratory manual, see Sample #10 on the following page.

Science Texts (Secondary Schools)

Most of the modern-day science texts are laboratory oriented. These texts are used by more schools than the programs developed nationally. They are essentially programming devices to aid the teacher in leading the student through a series of discovery experiences. Many of these texts are alo available with prepackaged student laboratory materials.

Content emphasis in the junior high is most frequently divided into the areas of life, physical, and earth science. While not always the case, life science is offered at the lower end of the spectrum, grade 7, and earth science is used with those children in grades 8 and 9. The following is a partial listing of some of the available titles.

Life Science	Physical Science	Earth Science
Exploring Life Science	Exploring Physical Science	Exploring Earth Science
Life and Molecule	Energy and the Atom	Our Planet in Space
Challenge to Sci. Life	Challenge to Sci. Physical	Challenge to Sci. Earth
Basic Life Science	Basical Physical Science	Basic Earth Science
The Biological Science	Physical Science	Earth and Space Science
Life Science/Search for Understanding	Physical Science/Search for Understanding	Earth Science/Search for Understanding
Modern Science/Earth, Life, Man	Modern Science/Material Energy	Modern Science/Earth, Space, Environment

At the high school level, biology is usually offered in grade 10, chemistry in grade 11, and physics in grade 12. The following is a partial listing of some available texts in these courses.

Biology Texts		Chemistry	Physics
BSCS	Green version	CHEM STUDY	Project Physics
	Yellow version	Chemistry, Experiments and Principles	PSSC

[Cont.]

SAMPLE #10

Experiment III

HUMAN HORSEPOWER

In the first chapter of the MAN-MADE WORLD reference is made to an attempt to propel an airplane by using the muscle power developed by a man as the energy source. Studies of the weight to power ratio of animals show that man should be capable of supporting himself in air for short periods of time. The problem is not only of supplying the motive power but also of obtaining lightweight material for wings of large surface areas.

Before determining the horsepower developed by a man, it is essential that certain terms be defined.

Horsepower:	One horsepower equals 550 foot-pounds per second
Foot-pound:	The work accomplished when a one pound force pushes something through a distance of one foot[1]

If a 120-pound person raises his body from any level to a position two feet above the original level, he will have done 120 pounds X 2 feet or 240 foot-pounds of work.

To determine the time rate of work, a measure of the time required for the action is essential. Dividing the work done (foot-pounds) by the time in seconds will give foot-pounds per second.

A horse is considered to be able to work at the rate of 550 foot-pounds per second for an extended period of time. Comparison of your rate of working with this standard will show your horsepower.

Your text explained that in going to a higher floor, more power is developed if stairsteps are mounted two at a time. Let us verify this statement.

Since

$$\text{H.P.} = \frac{\text{Force} \times \text{vertical displacement}}{550 \times \text{seconds}}$$

To determine our horsepower we need to know:

1. The force applied (your weight) ____________ pounds.
2. The vertical displacement (distance between floors) ____________ feet.
3. The time required for the displacement ____________ seconds. The 550 is a constant or proportionality factor.

Items 1 and 2 will remain fixed during the experiment. However, time will vary, hence a record will have to be kept for each trial.

* 1. Prepare a table to record your data.

After obtaining the data for items 1 and 2,

a. Find the time in seconds required to walk at normal speed as you climb a flight of stairs. Record the time required in the table.
b. Find the time required to climb the stairs taking two stairsteps at each step. Record.
c. For your final trial, find the time required if you climb the stairs as quickly as possible, supplementing your leg muscles by using your hands to grasp and pull on the hand rail. Record.

---

[1] The displacement must be in the direction in which the force is acting.

• 2. Calculate the horsepower generated in trials a, b, and c.

• 3. Reference Work

Obtain statistics which give the total weight of the plane and the maximum power developed by the engine of three types of airplanes:

a. Light private aircraft
b. Commercial aircraft
c. Military aircraft

• 4. Calculate the weight per horsepower of 3 a, b, and c.

• 5. How does each compare with the weight per horsepower generated in your maximum effort?

SOURCE: THIS EXPERIMENT IS INCLUDED WITH THE EXPRESS PERMISSION OF THE ENGINEERING CONCEPTS CURRICULUM PROJECT (THE MAN-MADE WORLD), STATE UNIVERSITY OF NEW YORK AT STONY BROOK.

Biology Texts

BSCS [Cont.] Blue version
Red version

Modern Biology
The Science of Biology
The Spectrum of Life

Chemistry

CHEM STUDY [Cont.]
Chemistry, An Investigative Approach
Chemistry, Experimental Foundations
Modern Chemistry
Chemistry, Patterns and Properties

Physics

Modern Physics
Concepts in Physics
Physics for High School

The present generation of texts is no longer intended to be an end in itself. The texts are recommended as devices to help students gather and interpret data. Questions should not be presented as a termination of learning, but rather should be interspersed throughout the learning experience. Students are no longer presented with three or four pages of reading material followed by a series of questions and a "cookbook" experiment. The text, questions, and experiments are related in such a way that the student uses them realistically in the process of gathering additional data in a particular area. The experiments themselves do not provide all the "answers" but rather open additional areas of interest and investigation.

Unified Science Programs

The idea of teaching unified or integrated science is not new. The division of science in the high school years into chemistry, biology, physics, and earth science has been questioned periodically. Unified science is a three- or four-year course which covers all disciplines in terms of their relationship to each other.

The following four statements serve as a rationale for the development of Unified Science courses (Schowalter, 1964):

1. Natural phenomena have no inherent properties that make them the exclusive "property" of chemistry, botany, or any other discipline.
2. The scientific disciplines are intellectual conveniences that facilitate specialized study.
3. Science education through the secondary school should be general rather than special if the goal of a scientifically literate citizenry is to become a reality, and if the many pure and hybrid disciplines are to attract individuals for research specialization.
4. Scientific inquiry has evolved processes (e.g., measurement) and theoretical concepts (e.g., equilibrium) that are used in, and are basic to, all disciplines.

Unified Science courses are built upon conceptual schemes and their relationship to each other. Emphasis is placed on unifying areas of each discipline rather than on the classification of activities into various disciplines. The very essence of this approach demands that continuity be maintained in the presentation of the subject matter and continued attention be directed toward unifying ideas. The purpose of this approach is not to hide the fact that there are science disciplines, but rather to enhance the understanding of the structure of science.

The following are examples of some of the unifying themes used in the program at the Monmouth Regional High School:

1. Matter is composed of fundamental particles which may be transferred into energy and vice versa.
2. Matter exists in the form of units which can be classified into hierarchies or organizational levels.
3. Units of matter interact.
4. All matter exists in time and space.
5. Living matter is characterized by its ability to carry on the functions of metabolism.
6. Man plays a unique role in nature as he uses his understanding of changes in matter and energy in attempts to control his environment.

Some Aspects to Be Considered in Adopting or Developing a Science Curriculum

Developing a realistic science curriculum from kindergarten through high school is at best a difficult job. Such questions as What units can be taught at what grade level?, What are the students capable of learning?, How much will it cost?, and How will it fit into the existing sequence?, must be seriously considered. While it is possible to adopt one of the existing programs and simply "plug it in," a good science curriculum should be designed to meet the needs of each system.

The placement of individual units or area of content covered by grade has for many years been a source of controversy in our schools. This problem is especially acute at the elementary and middle school levels in light of recent advances in the stage theory of intellectual development. It appears best not to consider a unit or concept learned or understood simply because it has been covered at one grade level. Repeated experiences in the same area allowing for increased sophistication on the part of the students is considered a useful approach. The main problem then becomes one of sequencing rather than strict grade level placement. The sequence constructed or chosen should provide for continuity of concept formation and introduction of new material on which a child can structure additional knowledge. Keeping a close check on sequence will eliminate the student having the same unit on the "Human Body" year after year.

While the teacher, department chairman, or curriculum revision committee is often anxious to provide more material and in-service training in its proper use, many of the "newer" programs demand more than this. One of the most important aspects in the success or failure of any new program is the attitude change on the part of the individuals involved. In-service sessions provide a base upon which those involved can build their own attitude change. If this type of approach is not utilized, your "new" program will quite possibly become nothing more than new material being covered in the traditional manner.

While a great deal has been said about the importance of sequence in programs, there should be time for investigations into areas not specifically written into the curriculum. Just because weather is not studied in grade 3 does not mean that we cannot discuss the hurricane we are having. Controversial issues, which appear without warning, such as drugs or local environmental problems, should also be allowed to "fit" somewhere at each grade level. Since science or the teaching of science is really a way of thinking or approaching a problem, time should be available at all levels for investigation into relevant topics.

Some Possible Sequences in Science Programs

K-6 Various programs from textbook publishers or programs such as SAPA, SCIS, ESS, COPES, CIS, ESLI, or STEM

7-8 Life Science, Physical Science, or Earth Science such as IMB, IET, or a sequential program such as ISCS

	Academic	Accelerated	General
9	Physical or Earth Science. IPS, ISCS, ESCP	Biology IME	Physical Science or Earth Science. ISCS, IIS
10	Biology BSCS, Green, Yellow, Blue. Other texts	Chemistry	Biology BSCS, Yellow or Red IIS
11	Chemistry CHEMS, CBA Other Chemistry texts	Physics	PS II, IIS Consumer Chemistry Allied Health Electricity
12	Physics PP, PSSC, ECCP Other texts	Electives in Advanced Science. See chart below.	Allied Health Electronics

Some Electives Currently Offered in Connecticut Schools

Quarter, Semester, or Full-year Courses

Animal Science
Astronomy
Cell Biology
Clinical Lab Techniques
Electronics
Environmental Science
Evolution
Genetics
Horticulture
Instrumentation
Limnology
Marine Biology
Meteorology
Microbiology
Oceanography
Plant Anatomy
Plant Physiology
Zoology, vertebrate
Zoology, invertebrate

Independent Study
Laboratory Techniques
Nature of Scientific Thought

Key to Some Science Courses

BSCS.	Biological Sciences Curriculum Study -- Prentice Hall, Rand McNally, Houghton Mifflin
CBA.	
CHEMS.	CHEM Study - Chemical Education Materials Study -- Prentice Hall, D. C. Heath, Houghton Mifflin
CIS.	Concepts in Science.-- Harcourt Brace Jovanovich
COPES.	Conceptually Oriented Program in Elementary Science -- New York University
ECCP.	Engineering Concepts Curriculum Project -- McGraw-Hill
ESCP.	Earth Science Curriculum Project - The Man Made World -- Houghton Mifflin
ESLI.	Elementary Science Laboratory Investigation -- Rand McNally
ESS.	Elementary Science Study -- McGraw-Hill
IAC.	Interdisciplinary Approaches to Chemistry -- Harper Row
IET.	Interaction of Earth and Time -- Rand McNally
IIS.	Ideas and Investigations in Science -- Prentice Hall
IMB.	Interaction of Man and the Biosphere -- Rand McNally
IME.	Interaction of Matter and Energy -- Rand McNally
IPS.	Introductory Physical Science -- Prentice Hall
ISCS.	Intermediate Science Curriculum Study -- Silver Burdett
PCP.	People Concepts Processes -- McGraw-Hill
PP.	Project Physics -- Holt, Rinehart and Winston
PSNS.	Physical Science for Non-Science Students -- Wiley
PSSC.	Physical Science Study Committee -- D. C. Heath
SAPA.	Science a Process Approach -- Ginn and Company
SCIS.	Science Curriculum Improvement Study -- Rand McNally
STEM.	Space Time Energy Matter -- Addison-Wesley
TSM.	Time, Space and Matter -- McGraw-Hill

PROGRAM EVALUATION

A science program involves the bringing together of many elements. In order to reach an evaluation it is necessary to consider all elements of the program and then consider how well they blend together. One way of checking the appropriateness of a science program is to go through the New England Association of Schools and Colleges (NEASC) evaluative criteria. It is very comprehensive and covers all levels of science programs. This should enable you to determine strong and weak areas in your program. Another device which may be used is a document published by the National Science Teachers Association entitled "Conditions for Good Science Teaching in the Secondary Schools."

Curriculum, Program-Course, Learning Experience

Curriculum may be defined as the totality of learning experiences of a student as a result of the planning and administration of a school system. It is also possible to talk about more limited areas of the curriculum such as the high school curriculum or the elementary school curriculum.

Program is a subdivision of the curriculum and is usually organized around a generally recognized academic discipline such as mathematics, language, science, or art. A course is a subdivision of a program. It is an articulated block of learning experiences ranging from the length of a mini-course to a full year.

A learning experience is a single integrated activity which leads the student to mastery of a single skill, concept, or objective. They are the links which form the foundation of education. A learning experience, for example, may consist of a 15-minute exercise whereby a student learns to read the "6" scale of a slide rule. A number of such learning experiences taken in sequence can lead to a more complex skill such as multiplying two 3-digit numbers on a slide rule.

Philosophy

Stating a program's philosophy is an important step in the evaluation process. Stemming as it does from the needs of the student body and the aspirations of the community as reflected in the school's overall philosophy, it will serve as the standard against which program evaluations will be made.

Once broad aims of the science programs are outlined, the goals and objectives can be written. Goals and objectives are merely more precise statements of the philosophy. Each general statement in the philosophy will generate several goals. Each goal in turn will generate several objectives. This is shown in the following:

- Philosophy
  - Goals
    - Objectives
      - Performance Objectives

The top step, Philosophy, represents the most general statements of purpose and each descending step represents increased specificity. Performance objectives are the most specific of all, outlining as they do the specific behavior to be elicited from the student. It can be seen that for each statement in the philosophy a large number of behavioral objectives can be generated.

If the science program's philosophy is likened to an architect's rendering of a proposed building, then the performance objectives of the science program are like the working blueprints. It is these performance objectives that are used in planning the learning experiences and daily activities of students. There are several steps separating the daily activities of students from the overall science program philosophy, but if the work has been done carefully and with regard to logical consistency, the daily work of students will be a true reflection of the philosophy of the program. Although this may seem to be a monumental task, it must be remembered that all these objectives do not have to be original. There are many sources which can be referred to such as the National Assessment of Education Progress and the Instruction Objectives Exchange. Many textbook series also list desirable objectives. What is important is that these objectives are realistic and relevant to the school and students.

Scope, Sequence, and Variation

Scope refers to the amount or depth of the material to be covered. Sequence refers to the order in which the material will be presented and variety refers to the options available to students or teachers. Once the goals of the program have been established, the appropriateness of the order of presentation or sequence must be determined. What concepts can be presented in the early years? Which concepts have to be postponed until the student develops a little more sophistication? What kinds of activities are appealing to different age groups? How can material be organized so that future work will reinforce and define skills learned earlier? Variety is also important. What optional activities or how much deviation from the normal sequence will be allowed to accommodate different student interests or abilities?

Development of Learning Experiences

Having decided on the goals to be reached the task is to develop a series of learning experiences which will lead the students to the desired goals. This can be done in varying degrees of specificity. It is possible to break down one's goals, objectives, and performance objectives into yearly blocks. The learning experiences are then constructed based upon those blocks. It is possible to break the yearly blocks down still further into "units" and develop learning experiences based upon the individual unit. The most specific approach is to plan each learning experience in detail, including student activity, materials to be used, time allocation, and a testing procedure used to help evaluate student progress. Several of the major elementary science programs have done this. Since detailed planning is a formidable task, there will be strong temptation to adopt a commercial program. This is fine if it meets the needs, or can be modified to meet the needs, of the students and the school.

Testing

Tests of student performance are many and varied, although the most common is the paper and pencil type instrument. The purpose of tests is to determine whether a student has developed a skill, concept, or attitude. In evaluating the usefulness of a learning experience, not only is student progress important but also the effectiveness of the learning experience itself. Considering the time allocated and the resources used, what percentage of the students is expected to be successful with the learning experience? If too low a percentage of students is successful, the learning experience may have to be modified.

A suggested procedure for developing a program is as follows:

1. Determine the goals, philosophy, and objectives of the program.
2. Select the concepts, skills, and attitudes which conform to the philosophy, goals, and objectives.
3. Order these into a sequence (some, of course, will be parallel).
4. Determine the degree of mastery expected.
5. Determine which variations are acceptable. (For enrichment, remedial, or variations in interest.)
6. Determine what learning experiences are indicated.
7. Determine what evidence of student progress will be accepted.
8. Determine what materials and equipment are necessary.
9. Determine approximately how much time will be devoted to each learning experience.
10. Determine what success level is to be expected.
11. Evaluate.

Evaluation can now consist of a series of yes-no answers. For example, suppose that 100 percent success is expected from students in the fifth grade with regard to a skill in the use of the metric system. However, only 50 percent exhibited this mastery. To determine the area of weakness simply go down the list above and change each statement to a question.

You may wish to compile a checklist as follows:

1. Is skill in the metric system a worthwhile goal?
2. Are the concepts selected appropriate to this goal?
3. Is the fifth grade an appropriate place to introduce this skill?
4. Is the degree of mastery reasonable for fifth grade students?
5. Are the learning situations selected appropriate?
6. Are the instructional strategies appropriate for the class?
7. Has the acceptable level of student performance been defined?
8. Are there sufficient materials, equipment, and supplies?
9. Is sufficient time being allowed?
10. Is a reasonable success level expected?

The above checklist should be of some help in isolating areas of difficulty in a program and in indicating where the action should be taken.

Assembling Courses into a Program

Make a flowchart of all course offerings. Represent each course with a box and arrange them in the order that students will progress from one to another. Courses given at the same time are arranged side by side. Some courses will feed into others. There will probably be several major pathways taken by pre-science, pre-college, and pre-technical students with variations provided for students who do not fit into these categories. Some imagination will be necessary to provide alternative arrangements for those students who are not college bound but for whom exposure to science is desirable. In analyzing a science program the following questions should be asked? Is the program tracked? Does it allow changeover for students whose goals change with time? Are there dead ends? Does a student find himself finished with one course with no place to go? Are there consolidations that could be made? Are there cracks in the series so that students who fail one course have no recourse but to repeat it? Finally, how does this program compare with that which is currently in the school? It should be fairly easy to decide upon a plan of action to implement the new program.

Course Selection and Development

Each box on the flowchart represents a course (an example is given below). The goals you have for each box should be determined. There is a vast selection of science courses currently available. Determine which meet the needs of the student. Adopting a nationally developed course is often easier than developing courses locally; therefore, these courses should be appraised. What claims are made for them? What goals do they purport to reach, what skills and learnings do they claim to impart? How have they been evaluated? For those courses developed to meet special local needs, it will be useful to follow the procedure outlined in the previous section. Often other districts will have a similar course in operation. It can be useful to poll surrounding districts or contact the State Department of Education to learn about these.

Types of Testing

Once a program of study has been set up, it is important to determine its effectiveness with the students in the school. There are three domains which should be examined: the cognitive, affective, and psychomotor. Measurements in the cognitive domain are the easiest to make and there are a large number of pencil and paper instruments which purport to do both for general science information and for more specific purposes. The National Science Teachers Association publishes a booklet which lists a large number of such tests and gives a short description of each.* In addition, most of the nationally funded curricula which have been developed have their own written examinations. Many of the nationally available examinations give norms which allow comparisons to be made between the achievement of local students and others on a national scale. Care must be taken in making comparisons. If the local school does not fall neatly into one of the urban, suburban, or rural groupings often used for norming purposes, comparison may be especially difficult. Consideration should be given to the use of criterion referenced tests. These do not use norms, but determine the progress of the class toward a particular objective. Many items of this type have been developed and are readily available.

In trying to evaluate the affective domain, there is much less available in the way of paper and pencil instruments. Yet this remains a very important area of student growth to be assessed locally. Less objective methods can be developed. One way is to make a checklist of student behaviors that exemplify attitudes felt to be important, and then periodically make a sample survey. The checklist might contain such items as:

> Do the students come to class prepared?
> Do they actively take part in class discussions?
> Do they voluntarily read science-related books?
> Do students volunteer to do outside work?
> How many actively patronize the science club? ecology club? etc.

This procedure will give an indication of the general attitudes of students toward science. The psychomotor domain involves manipulative activities. Science educators should not only stress the importance of accurate measurement, but they should check students to see if they can in fact measure accurately. Every science course involves some manipulation of apparatus. Lab practicals and other situation tests should be used to check the level of manual dexterity shown by students. Some lab skills such as glass blowing, preparation of solution, development of apparatus may lead to careers.

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*Standardized Tests in Science NSTA

Course Development

Now there remains the problem of filling up the rest of the "boxes." Since these courses are unique to your school and are for the special needs of a particular group of your students, here is where the procedure outlined for the elementary school applies. You will have to follow the ten steps listed on page

Having successfully done the above, you may now have a complete science program which is tailored to the unique needs of your student population. Is it any good? By repeating the two questions posed at the outset you can answer this question. Assuming that this has taken you considerable time to accomplish, it is probably time to start around again. Since education no less than any other human activity is not static, program evaluation involves a continuous process. As a matter of practicality it might be well to develop a plan of reevaluation that is tied into the ten-year accreditation process.

Summary

Since the average elementary school has a complete change of population every six years, the average junior high every two years, and the typical high school every four years, it is clear that this means constantly changing goals and objectives on the part of the student body. The science program must be constantly changing to meet these ever-changing needs. Program evaluation then is a dynamic process. As the pace of scientific and technological change accelerates so also must the pace of program development and evaluation if it is to keep pace. It cannot be overemphasized that a science program can only be evaluated in terms of its own philosophy which in turn must be rooted in the hopes and aspirations of the community and its children. At any given point in time, the science program can be evaluated by answering one question: How well does the science program meet the needs of students?

SCHOOL SCIENCE FACILITIES

Elementary School

The science facilities required in the elementary school, as with any level, are as limitless as a teacher's imagination and budget. Obviously, it is impossible to anticipate the diversity that idealistically could occur. However, there are several common features that should be available to conduct an efficient activity-centered program in any school. Regardless of the science program implemented, it is desirable to make the facilities as flexible as possible to accommodate large and small group instruction, independent study activities, personalized programs, and changes necessitated by an evolving curriculum of science for the future.

Realizing the financial stress that new curricula and associated facilities put on the budget of a school system, many of the newer science curricula are designed to function under existing educational environments. In the public schools of Connecticut, the K-5, K-6, or the K-8 sequence accounts for approximately two-thirds of the elementary schools, with the majority following a K-6 structure. Since this diversity also occurs at the national level, the elementary science curricula developed for maximum application have been organized around the K-6 core. Most of the programs assume that elementary school teachers are not science specialists and that they teach in self-contained classrooms. With these guidelines science is usually taught in an elementary classroom and is structured around intraclass activities performed by individuals or small groups. The units and individual lessons are developed around common materials which do not entail unusual or elaborate quipment. Therefore, a teacher or aide can assemble the necessary learning materials from local sources in the community or the surrounding area. It is also possible to purchase kits or prepared lessons from various educational supply houses. The advantage in the commercially packaged units is the lesser amount of time required to accumulate materials. Most units come in their own containers which are suitable for classroom storage.

Keeping the science curriculum as an integral part of the interdisciplinary atmosphere of the elementary environment, materials and activities should not be isolated from normal class functions. However, the classroom should provide the following: a section for storage of nonperishable substances; an area exposed to sunlight; facilities for animals required for extended observations; a work area for students to do individual or personalized science activities; a portion of the room allocated for the retention of experiments that extend over several days; and means for obtaining and discarding water. Any experiments requiring electricity, such as Batteries & Bulbs, can utilize common batteries or dry cells. In units needing heat, candles or sterno can be used. Once these preliminary materials are obtained, the room will be equipped to provide a continuing program regardless of the curriculum.

In schools where the classrooms are self-contained, the following room organization suggests one arrangement of facilities for carrying on most of the elementary science programs. (See Figure 1.)

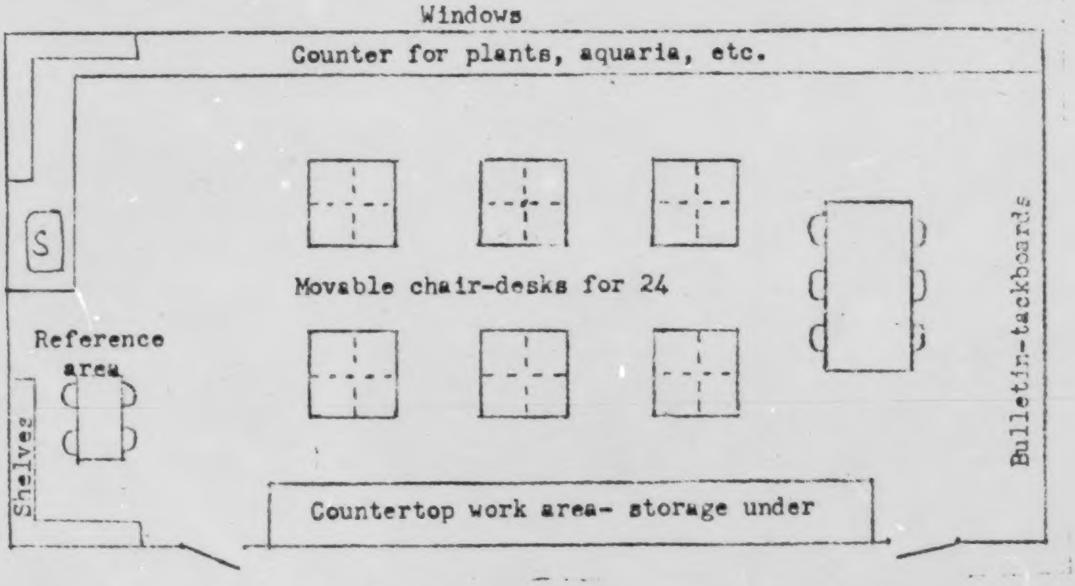

Windows
Counter for plants, aquaria, etc.
S
Movable chair-desks for 24
Reference area
Shelves
Bulletin-tackboards
Countertop work area- storage under

Figure 1

A Possible Classroom Arrangement for Science

When school systems allocate particular segments of the day for science, the entire classroom can momentarily be restructured to meet the needs of the particular lesson, but when the curriculum is structured around the open class concept, space requirements are substantially increased. Facilities must continuously provide a diversity of readily accessible lessons; work areas that range from desk tops to sinks; several disposal areas appropriate for materials consumed; and the organization to meet the demands of fluctuating numbers of students engaged in a variety of science investigations all at different stages of completion.

One disadvantage in using the typical elementary classroom is the difficulty in conducting individualized or personalized experiments. To provide for individualization, some schools have adopted a science program under the guidance of a science coordinator or consultant who directs a science center with the assistance of other members of the staff.

An alternative is to have the consultant use the teacher's room for the various lessons and the center for special activities.

The center itself may be an area used primarily for consolidation of materials and equipment and the dissemination of packaged lessons for daily or weekly use. It may also be a work area containing electrical, gas, and water outlets. Along with these facilities, there is usually sufficient table space and room for several diverse activities to be conducted simultaneously. The science center has other advantages in that it can provide the opportunity for students to conduct experiments without disturbing other students. The center could be open on a continual basis enabling students to do experiments during the day as their schedule permits. The floor plan shown in Figure 2 provides one means of organizing a science center.

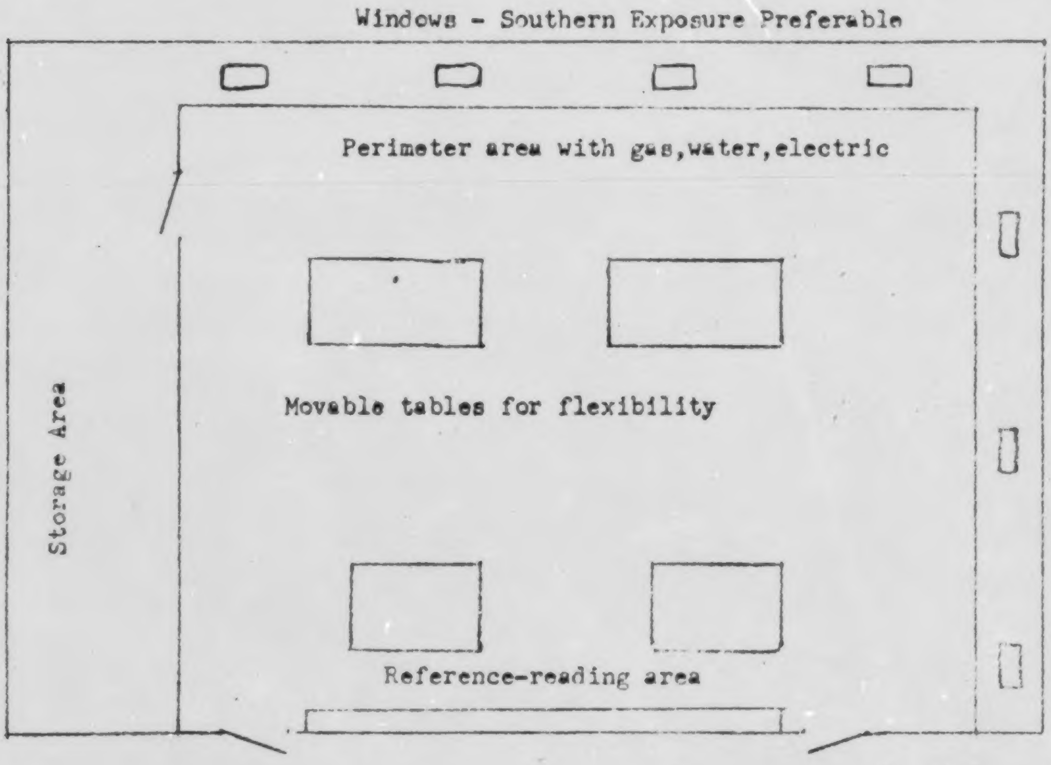

Windows - Southern Exposure Preferable
Perimeter area with gas,water,electric
Storage Area
Movable tables for flexibility
Reference-reading area

Figure 2

Possible Floor Plan for a Science Center

A science center enables a school system to purchase materials for a particular curriculum without duplicating units for every classroom.

Some centers contain activities from more than one of the newer curricula to further stimulate personalized science investigations.

In an attempt to utilize many forms of learning experiences, some systems have established learning centers with a nucleus consisting of a library and reference area as shown in Figure 3. The science facilities contain all the advantages of a science center, and audio-visual and other materials are easily accessible without taking up valuable laboratory space. The learning center also enables students to conduct investigations in one area and momentarily go to another room or center for supplementary information or materials.

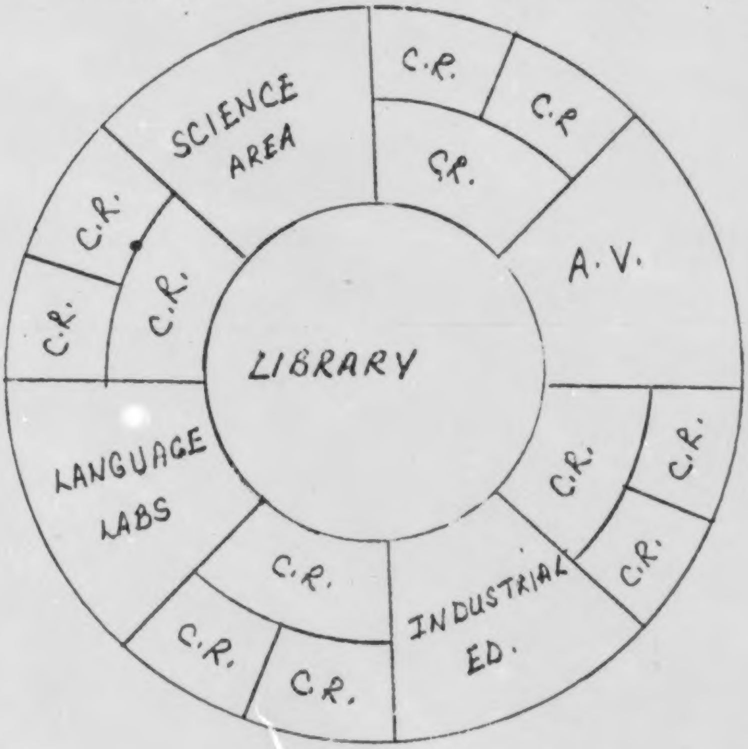


Figure 3

Learning Center Established in Some Systems

In light of the many new science curricula already available, it is important that facilities in elementary schools be made available for their implementation. These facilities will depend upon the philosophy of the school and its approach to instruction.

Secondary School Science Facilities

General Considerations

I. Flexibility

Science facilities should be planned for the existing curriculum but with sufficient flexibility to meet the needs in the future. Muti-purpose laboratories are preferable to single-purpose labs, and flexible, movable lab tables and benches are preferable to massive, stationary lab furniture.

II. Room Size

Room size should be variable and planned for a wide range of activities from seminar-type rooms to accommodate 5 to 10 students to large lecture-activity rooms seating 100 to 150 students. Availability of space for individual work or long-term projects is desirable.

III. Storage Facilities

Centralized storage facilities are quite common in newer buildings. Laboratory aides or technicians may work in this area to supply the needs of all labs and individual student projects. In designing the science area, decentralized storage facilities may have advantages by lessening the movement of apparatus and equipment necessary. It is desirable to have most of the equipment and materials in the room where the apparatus is to be used, but much equipment, because of expense or limited use, may be shared and some central storage area is probably desirable. Storage spaces between science rooms for convenience should be considered. Open shelving, rolling carts and racks are handier and less expensive than enclosed cupboards and cabinets.

IV. Specialized Rooms

Plant rooms, animal rooms, self-study carrels, and independent study areas are desirable features to be incorporated in new science areas. In-room library areas with magazines and reference materials can be designed to make these materials readily available.

Laboratory Arrangements

The possible arrangements for laboratory layouts are practically endless. However, most laboratory arrangements follow three general patterns. These are the perimeter, the island, or the long, straight-table type. Each style has certain advantages and should be studied carefully before making a final selection.

The perimeter layout locates the laboratory workspace around the walls of the room. This may be a straight-table type or there may be tables placed perpendicular to the walls to give additional space. Water, gas, and other desired service is available to all stations. With movable tables or tablet arm chairs in the center of the room this setup has much flexibility for various activities.

The island-type lab space may have rectangular, square, or octagonal shaped tables. These may be serviced from an island which is permanently (and in some recent instances, temporarily) located in the room, but the tables are movable so that different arrangements are possible. A separate area is available for tables or chairs for non-lab activities.

The long, straight-table type lab bench with service pipes and trough sinks running the length of the table to service students on both sides of the bench is the style most common for many years. There is little flexibility to this setup and it is not seen very often in newer buildings.

Types of Lab Activity

Some lab activities are best accomplished with the student seated and a standard table height of 30 inches. Many biology experiments utilize this table height. Most chemistry experiments are performed with the students standing and the bench height 36 inches. Stools or chairs for the proper height table allow both standing and sitting activities to be pursued comfortably. Combining a perimeter setup for standing activities with islands or tables for sit-down activities gives great flexibility.

Lecture-Labs or Separate Laboratories

It is well established that science courses should be laboratory-oriented. Many chemistry, physics, and biology courses meet for four or five lecture periods and one double period for laboratory each week. Laboratory activities may be conducted three or four times a week in the newer programs, a schedule requiring that laboratory activities be possible on any day the class meets. For this reason, it is desirable that the lecture-lab facilities be available whenever the class meets. In situations where a separate laboratory is shared by teachers, this flexibility for laboratory activities is not available.

Planning for the Future

A typical junior high school with grades 7-9 will offer three years of science to all students. The courses will probably be a physical science course such as IPS, a biology or life science course, and a course in earth science. The high school with grades 10-12 will probably offer biology, chemistry, and physics with various high and low sections, and possibly Advanced Placement courses. There is a trend to offer courses in ecology-oriented areas, oceanography, meteorology, and some specialized courses.

As part of this rapid growth of facilities are planetaria and computer centers. These two facilities can be provided on a regional or a local basis through the use of state and federal assistance. Unlike some of the school facilities mentioned previously, the planetarium and computer center have the advantage of being applicable through the entire science program from K to 12. At the primary level, the planetarium serves to simulate astronomical phenomena without the reliance on hours of observation. Gradually, the transition from basic observations to actual measurement and recording of data can be achieved with a simultaneous growth in mathematics. On occasion, planetarium facilities may also become emergency A.V. rooms or classrooms. However, since most planetaria serve an entire system or region, they are rarely unoccupied.

The values of a planetarium are also present for computer centers. Presently, computer science at the K-12 level is in its infancy, but there are new computer programs being developed in all branches of science. Besides the obvious need of understanding computers for anyone interested in a career in science, the facilities provide a nucleus for interdisciplinary studies with mathematics.

In planning new science facilities, a five- or ten-year projection is desirable, bringing together all the best information of town growth, student population, new courses, and staff availability. At present there is a trend showing decreasing enrollment in the elementary schools and if a town has a stable population this trend will also be showing up in the secondary school population.

Before committing any ideas on science facilities to paper, it is useful to visit as many schools as possible known to have exemplary science facilities. Discuss the science program needs with teachers in various schools and architects known for designing and building good facilities. The time involved in these excursions will be well spent and will result in better designed science facilities that will be functional for many years to come.

SCIENCE LABORATORY SAFETY

Introduction

Science instruction is becoming more and more activity oriented. The increase in new topics, new apparatus, and new teaching techniques over the past years has emphasized the importance of the safety aspects of science instruction.

It is vital that each school have a science safety program and that administrators, science supervisors, science teachers, and science students be well versed in its procedures. A well-run, well-organized laboratory with a carefully thought-out safety program will provide a safe and appropriate environment for laboratory experiences. A poorly organized, lackadaisically run laboratory with a poor safety program, or even a good set of safety procedures which receive little attention, can lead to unhappy and sometimes tragic results. From a statistical point of view, there is a very small accident to laboratory activity ratio in science classrooms and laboratories, but each accident happens to an individual and statistics lose their meaning to the person who falls victim to one.

General Guidelines and Procedures

1. Supervision

a. Administrators play an important role in a safety program. In cooperation with the science department they should ascertain that the laboratory facilities and equipment meet state and local requirements. They should see to it that a formal safety program is designed and implemented. They should provide communication to the appropriate town authorities and to the community of the need for a safety program which provides facilities, equipment, and procedures designed to foster a safe science program.

b. Science supervisors and department heads should develop the details of the safety program and assure that these details are carried out. They should inform experienced teachers of new procedures and new regulations as they appear. They should provide training as needed for new teachers entering the science department. They should inspect laboratory and storage facilities to assure adherence to the guidelines and regulations currently in effect. They should provide overall supervision of the science program to determine the extent to which the safety program is being implemented and to determine what new procedures, equipment, or facilities are necessary for the program's improvement.

c. The science teacher has the direct responsibility or carrying out the safety program in the laboratory. Science teachers should ascertain that their students are aware of safety procedures in the laboratory. Teachers should make sure that students are thoroughly informed of any particular dangers which may be associated with the particular experiments they are conducting. Horseplay should not be allowed in a safety-conscious laboratory situation. Teachers should also be of help in informing students of safety procedures connected with out-of-school science projects or activities. Laboratory activities involve the continual movement and storage of chemicals and instruments. Teachers should supervise the safe manipulation and storage of these materials before, during, and after the science activities.

2. Beginning the Course

At the beginning of each science course students should be instructed in the general safety procedures to be followed. As specific safety procedures are necessary throughout the course, students should also receive instruction in them. Some school districts require that each student read the safety rules and sign a statement to that effect. These statements are kept on file.

Notify the science department and/or the principal at the beginning of each term or when a defect occurs of possible hazards such as:

a. defective gas fixtures, electrical outlets, or connections
b. defective laboratory furniture which may be hazardous
c. inadequate or inappropriate storage cabinets
d. ineffective or uninspected fire extinguishers, fire blankets, fire detectors, and other safety devices

Eye goggles, face shields, or other protective devices must be worn during "any work, activity or study in a public or private elementary or secondary school laboratory or workshop where the process used tends to damage the eyes or where protective devices can reduce,the risk of injury to the eyes concomitant with such activity. . ." (1), (2). The use of eye protective devices is required by state law.

Aprons, gloves, or other protective equipment should be worn to protect the student and his clothing as warranted by the particular activity. The decision to use such protection should be made by appropriate science department personnel.

Laboratory safety charts are available from equipment concerns. These charts can be placed at conspicuous places in the laboratory as a continual reminder that safety procedures should be observed.

3. Facilities and Storage

A good safety program requires appropriate facilities and storage areas. Facilities are, of course, easiest to provide for when a building is being designed. However, existing facilities can be and often must be modified to meet the requirements for a safe science program. The following checklist includes a number of the requirements and recommendations for science laboratories.

	Required	Recommended
Fire extinguishers (3)	X	
Fire blankets		X
Fire detectors (unless bldg. is sprinklered)	X	
Emergency showers (4)	X	
Eye bubblers (4)	X	
Fume hoods (chem labs) (5)	X	
Exhaust systems to exterior(5)	X	
Fire exit instructions posted in conspicuous place	X	
Flammable materials storage cabinets (6)	X	
Master gas shutoff valves (7)	X	
Nonflammable, self-closing rubbish containers for self-combustible materials	X	
Master electric shutoff switches		X
Two remote means of egress (8)	X	
Limit on amount of stored flammable chemicals (9)	X	
Proper labeling of storage cabinets (10)	X	
Separation of flammable liquids from flammable gases (11)	X	
Inside storage room ventilation (12)	X	
Storage of flammable materials in explosion proof refrigerators (13)	X	

a. Room Areas and Traffic

Science activities require a good deal of manipulation of apparatus as well as movement on the parts of both teachers and students. As a result, it is important that sufficient footage be made available for both the safe transportation of chemicals and delicate instruments, and the safe manipulation of these materials at the student's workspace. For construction purposes at the elementary school level, a minimum of 30 square feet per student station (including storage) is required. (14) However, 35 square feet per student station is recommended.(2)

Again, for construction purposes, in the middle school (grades 5-8) a minimum area of 35 square feet per student is required and 40 square feet per pupil is recommended. At the secondary school level, a minimum of 47 square feet per student station (including storage) is required, with 53 square feet per station recommended. (15) The National Science Teachers Association in its publication Conditions for Good Science Teaching in Secondary Schools states that "a reasonable rule of thumb is that there be a minimum of 45 square feet (5.5 square meters) of space per student if the room is a combination classroom-laboratory, and a minimum of 35 square feet (4 square meters) per student if the space is strictly for laboratory." (16) Traffic patterns should also be considered. Since chemicals are often carried around the room, or in case of an emergency, it is important that sufficient space be available for easy movement by both teachers and students. There should be no "traps" between lab benches which could cause congestion in case of fire or other emergency.

There should be "free passage" areas for fire or other emergency purposes. Those areas should be at least 2 feet 6 inches wide (the distance required for two people abreast) and should remain unobstructed by chairs, tables, stools, or apparatus.

b. Storage Rooms and Storage

A comprehensive set of guidelines appears in Appendix B-1. Some of the high points regarding storage rooms and storage are:

1. Storage rooms must be ventilated.
2. Ventilation and light switches must be located outside the door.
3. Storage containers for flammable or combustible liquids must not exceed one gallon unless the container is a safety can in which case it may hold two gallons.
4. Not more than ten gallons of flammable or combustible liquids outside of the storage room unless in safety cans in which case there is a twenty-five gallon maximum.
5. Storage cabinets for hazardous chemicals should not be located adjacent to exits.
6. All storage cabinets must be properly labeled as to the hazard of the contents such as "Danger--Keep Fire Away," "Danger--Do Not Use Water," "Radioactive Materials," etc.
7. Gases which support combustion must be stored away from gases that will burn.
8. Acids and bases should be kept separate.
9. Flammable liquids should be stored in and dispensed from approved containers only and should be returned to the storage area as soon as possible after use.

4. First Aid

Even with an effective safety program, accidents will occur in the laboratory from time to time. Often these accidents are of a type which require direct action on the part of the teacher.

A first aid kit should be kept in each laboratory and placed at an easily accessible spot. The kit should contain items such as: standard antiseptic, bandages, sterile gauze dressings, burn ointment, adhesive bandages and tapes, and cotton balls and swabs. A wall chart on emergency treatment procedures is available from the American Red Cross. First aid courses are also offered by that organization. The most common types of accidents to occur in the laboratory are cuts, and burns from flames or acids and bases.

Treatment for cuts include stopping the bleeding, cleansing the wound with antiseptic, and providing an appropriate cover or dressing. Time permitting, the school nurse or physician should be contacted to perform this procedure. The student should be examined by these medical personnel in any case. In case of a flame burn, the student should be sent to the school nurse or physician for treatment. For acid burns, the area affected should be flushed with large quantities of water and then neutralized with a paste of baking soda, soap suds, or a mixture of limewater and oil. If the acid is splashed into the eye, flush with copious quantities of water and wash with lime water. Contact the school nurse or physician. For burns from bases, flush the area with water and neutralize with a citric juice or vinegar solution. If the base is splashed into the eye, flush with plenty of water and wash with a weak solution of vinegar. Again, call the school nurse or physician.

5. Activities in the Laboratory

Student activities in the laboratory involve a broad number of possibilities which can prove to be dangerous. The following listing will indicate some general recommendations and some recommendations to be considered when working in the physical or biological sciences laboratory.

a. Suggested Safety Procedures--General

(1) Prohibit eating or drinking in the laboratory.
(2) Acquaint all concerned with special procedures for each experiment.
(3) All experiments should be performed by the teacher before the students are expected to do it.
(4) Teachers should be advised to maintain a neat, orderly laboratory area. Do not allow materials to accumulate which may become a hazard.
(5) Plastic or earthenware jars should be provided for all non-paper waste. Broken glassware and chemical residues should not be placed in the paper wastebasket.
(6) Appropriate protective gear should be worn, as warranted by the experiment.
(7) All bottles should be labeled. Unlabeled materials should be discarded.
(8) Extreme care should be taken in handling corrosive or super cold materials.
(9) In inserting or removing electrical plugs, hold the plug, not the cord.

(10) Proper shielding and procedures should be effected when working with X-rays, ultra-violet, laser beams, or other radiations which may be hazardous.
(11) Inspect all glassware before using. Sharp edges should be smoothed and cracked glassware should be discarded.

b. Suggested Safety Procedures--Physical Science

(1) Do not use open flames when working with volatile liquids which are flammable.
(2) Proper shielding or evacuation of pupils to a safe distance should be observed whenever working with explosive mixtures or very reactive substances.
(3) Use the following precautions when inserting glass tubing into stoppers:
    (a) All surfaces should be smooth and fire polished.
    (b) Use water, soap solution, or glycerine as a lubricant.
    (c) Always aim the glass tubing away from the palm of the hand which holds the stopper or rubber tubing.
    (d) Always hold the glass tubing as close as possible to the part where it is entering the rubber stopper.
    (e) The use of a cloth wrapped around the glass tubing or hand will help avoid injury if the glass breaks.
(4) Acids or organic volatile liquids should not be placed near heating pipes nor be allowed to stand in the sun; dangerous gas pressures may build up.
(5) Do not stopper bottles containing dry ice. Plug loosely with cotton or use a safety pressure cap.
(6) Avoid direct mouth pipetting. Use appropriate suction bottles or other safety devices.
(7) Waste rags, towelling, or swabs soaked in any volatile combustible substances should be disposed of in fireproof receptacles.
(8) Glass wool and steel wool should be handled carefully to avoid splinters.
(9) In evacuating glass bulbs for any experiments, wrap the bulb in a towel to avoid flying glass if the bulb should be crushed.
(10) Check the safety valve before using pressure cookers or other pressurized equipment.
(11) Prohibit the use of radioactive materials greater than those allowed under "exempt" amounts by the A.E.C.

c. Suggested Safety Procedures--Biological Sciences

(1) In handling flowers and bread mold care should be taken that pollen or spores are not excessively distributed throughout the classroom. Some students may be allergic to pollen or spores.
(2) Use only sterile needles or lancets to draw blood. Discard needles and lancets after use.

(3) Use fresh materials at all times. Keep necessary material refrigerated, or in appropriate preserving solutions or medium.
(4) Use pyrex or hard glass test tubes if the apparatus is to be heated.
(5) Electric heaters or water baths are preferable to open flame. Use only electric or steam heaters for volatile liquids.
(6) Scapels and dissecting instruments should be properly sterilized before and after experiments.
(7) Pathogenic bacteria should not be kept or used in the laboratory. A license is required.
(8) Dishes passed around for inspection should be taped in the covered state.
(9) Care should be exercised when heating nitric acid used in the protein test; also, exercise care in handling potassium hydroxide such as in the Biuret test. These chemicals are corrosive to the skin.
(10) Wire loops used for transferring cultures of bacteria should be flamed after each transfer is made.

6. Radioactive Materials

The use of radioactive materials for medicine, energy sources, and other scientific and technological endeavors is continually receiving greater attention. As a result, science teachers often introduce these topics into their courses. While a certain amount of radiation exposure is inevitable, it is important that exposure as a result of classroom experimentation be kept within established guidelines. Weak radioactive isotopes are available from commercial sources. Many isotopes, as approved by the Atomic Energy Commission, require no special license. It is recommended that for experimentation purposes teachers utilize isotopes of the type and in the amounts for which no special license is required.

A worthwhile handbook describing the use of radioactive isotopes in the laboratory should be obtained and kept on hand by teachers intending to perform activities in this area. The booklet entitled "Radiation Protection in Educational Institutions" (NCRP Report No. 32) is available for seventy-five cents from

NCRP Publications
P.O. Box 4867
Washington, D.C. 20008

Some general recommendations for the handling and storage of radioactive materials are:

(1) Containers of radioactive materials should be properly labeled. The label should carry the kind and amount of material and the word RADIOACTIVE or the standard radioactivity symbol.

(2) Materials should be stored in a locked cabinet with the words RADIOACTIVE MATERIAL or the standard radioactivity symbol in a highly visible place.
(3) Use tweezers, tongs, forceps, or other remote handling tools as appropriate. Wear rubber or plastic gloves. Wash hands after experiments and check with a Geiger Counter.
(4) Keep containers of radioactive solution closed except in use.
(5) Do not eat, drink, or smoke in the areas used for experimentation.
(6) Keep radioactive materials away from photographic film.

Any specific question regarding the safe usage, quantities, leakage, storage, or regulations pertaining to radioactive source or other sources of ionizing radiation such as X-rays can be referred to the Radiation Compliance Unit of the Department of Environmental Protection in Hartford, Connecticut.

7. Lasers

Lasers are being introduced into secondary school laboratories for use in activities in such areas as geometric optics, holography, and the measurement of the wavelength of the laser light. Most lasers used in schools are of the helium-neon continuous wave type. The most common wavelength is 6328A.

It is suggested that the maximum laser output for school use be 0.1 milliwatt. It is further recommended that the following guidelines, outlined by the American Conference of Governmental Hygienists, be adhered to when using lasers for classroom demonstration or laboratory activity.

General Precautions

(1) Personnel should not look into the primary beam or at specular reflections of the beam when power or energy densities exceed the permissible exposure levels.
(2) Avoid aiming the laser with the eye to prevent looking along the axis of the beam, which increases the hazard from reflections.
(3) Work with lasers should be done in areas of high general illumination to keep pupils constricted and thus limit the energy which might inadvertently enter the eyes.
(4) The laser beam should be terminated by a target material that is non-reflective and is fire resistant. An area should be cleared of personnel for a reasonable distance on all sides of the anticipated path of the beam.
(5) Avoid electrical shock from the potentially dangerous electrical sources of high and low voltage.
(6) Special precautions should be taken if high voltage tube rectifiers (over 15KV) are used because there is a possibility that X-rays will be generated.

Specific Precautions for Low-Powered Continuous Wave Gas Lasers

(1) General precautions with reference to aiming and the avoidance of specular reflection should be observed.
(2) The laser beam should be terminated at the end of its useful beam path by a material that is a diffuse matte of such color or reflectivity to make positioning possible but should minimize the reflection.
(3) Reflective material should be eliminated from the beam area, and good housekeeping should be maintained.

8. Animal Handling and Treatment in the Laboratory

Much has been written about the treatment of animals used for instructional purposes. Less has been communicated regarding possible dangers to humans handling laboratory animals. In the area of animal treatment it should be remembered that Connecticut Statutes state that schools shall provide "instruction in the humane treatment and protection of animals." (17)

General principles to be observed in such treatment are:

(1) Animals should always be maintained under the best possible conditions of health, comfort, and well-being.
(2) No vertebrate animals should be subjected to any experiment or procedure which interferes with its normal health or causes it pain or distress.
(3) Any experiment which involves the use of vertebrate animals should be carried out by or under the personal direction of a person "trained and experienced in approved techniques for such experiments." (18)

A number of publications with comprehensive guidelines for animal care and treatment are available: (19), (20), (21), (22)

The following guidelines indicate some recommendations and practices in safeguarding humans in their handling of animals. (23)

(1) Develop a school policy of types, permission required, and length of time that warm-blooded animals (including birds) may be kept in the classroom.
(2) Develop policy on whether only animals from supply houses or research laboratories may be kept in classrooms.
(3) If animals act sluggish or are inactive for lengthy periods of time (several hours), contact a veterinarian or other appropriately trained person for diagnosis and possible disposal.
(4) Any student bitten by an animal should be attended to immediately and a report filed. The animal should be kept for examination by authorities.
(5) Maintain an alert for signs of animal sickness, including: sluggishness; unresponsiveness; loss of appetite; unusual odor; unusual discharges; skin color change; hair, eye

dullness; other animals in the same or nearby cages dead; frequent sneezing.

(6) Exercise care in giving students animals to take home.

(7) Avoid dissection of dead animals found in the field or on the highways.

(8) Wear gloves when working with live animals, and wash up both before and after exposure to them. Care should also be taken in the handling of other organisms, such as snakes, sea urchins, fish, and other forms of marine and land-bound life.

The previous sections deal with some guidelines for various types of activity in the laboratory. They are by no means all-inclusive. A good safety program will involve a knowledge of federal, state, and local laws and regulations as well as the expertise of the teacher in his area of specialty. Utilizing this knowledge to the fullest will minimize the possibility of accidents in the science laboratory.

Notes

(1) See complete law and regulations in Appendix B, V-1.

(2) A full explanation of the standards for design, construction, and quality of eye protective devices can be found in "USA Standard Practice for Occupational and Educational Eye and Face Protection," USA 87.1-1968. Information about the acquisition of such documents is available from the Connecticut Society for the Prevention of Blindness, Inc., 64 Wall Street, P.O. Box 2020, Madison, Conn. 06443, (203) 245-4700.

(3) See Appendix B,I, Section F VI, of *Storage and Use of Flammable and Combustible Liquids, Chemicals and Gases in Educational Occupancies*.

(4) Eye bubblers and showers can be one and the same. Eye bubblers, if to be used as showers, cannot be fixed.

(5) Where noxious fumes or flammable vapors are emitted.

(6) See Appendix B,I, Section II, of *Storage and Use of Flammable and Combustible Liquids, Chemicals and Gases in Educational Occupancies*.

(7) Only equipment within sight.

(8) Over 50 occupants or 1,000 square feet.

(9) See Appendix B,I, Section I A1, of *Storage and Use of Flammable and Combustible Liquids, Chemicals and Gases in Educational Occupancies*.

(10) See Appendix B,I, Section I B 1d, of *Storage and Use of Flammable and Combustible Liquids, Chemicals and Gases in Educational Occupancies*.

(11) See Appendix B,I, Section I C, D, & E, of *Storage and Use of Flammable and Combustible Liquids, Chemicals and Gases in Educational Occupancies*.

(12) See Appendix B,I, Section III E (a), of *Storage and Use of Flammable and Combustible Liquids, Chemicals and Gases in Educational Occupancies*.

(13) Refrigerators with "nonsparking" switches are available.

(14) *School Building Project Procedures,* The School Economy Series #1, State Department of Education, Hartford, 1965, p. 9.

(15) Ibid., p. 10.

(16) *Conditions for Good Science Teaching in Secondary Schools*, National Science Teachers Association, 120 16th Street, N.W., Washington, D.C. 20036. (See page 4.)

(17) Section 10-15 of the Connecticut General Statutes.

(18) See Appendix B,I, Connecticut State Board of Education Policy Statement re: Treatment of Animals Used for Instruction in the Schools.

(19) *Use of Live Animals in High School Teaching*, National Association of Biology Teachers, 1420 N. Street, N.W., Washington, D.C. 20005.

(20) *Guiding Principles in the Use of Animals by Secondary School Students and Science Club Members*, National Society for Medical Research, 1330 Massachusetts Avenue, N.W., Washington, D.C. 20005.

(21) *Principles for the Care and Use of Animals*, American Psychological Association, 1200 Seventeenth Street, N.W., Washington, D.C. 20005.

(22) The Laboratory Animal Welfare Act (7 USC 2131), Public Law 89-544, U.S. Department of Agriculture, Information Division, Washington,D.C. 20250.

(23) Guidelines are abstracted from "A Guide. . . Safety in the Science Laboratory," Bulletin 74, 1968, State Department of Education, Tallahassee, Florida, pp. 37-40. An additional useful volume is "Manual of Laboratory Safety" published by the Nassau County Science Supervisors Association.

SUPERVISION OF SCIENCE PROGRAMS

Supervision: Approaches and Methods

The primary concern of supervision is to provide the climate and conditions that are best for learning. The supervisor must remember that supervision is a human relations business requiring considerable skill and patience.

Be Service-oriented, Concerned Primarily with Adults

To be an effective supervisor, your major efforts should be directed toward the professional educators. Classroom teachers are primarily responsible for students in their classes, and the principal for improving the instructional program in his school. A supervisor should aid them in their efforts to provide better educational opportunities for the students in their schools.

Though a supervisor should be concerned primarily with adults, he cannot accomplish his task of aiding teachers and principals to improve the school program without keeping the students in mind. The student is the focus of all educational forces. The supervisor however, should be service-oriented to the principal and to the teacher. His job entails a human relations undertaking, requiring not only considerable tact, skill, and patience, but also learning to know the people with whom he works.

Get Acquainted with Teachers and Principals

Use Personnel Records. Personnel records should be consulted and information extracted from them that will be of use. Such records usually contain the teacher's scholastic qualifications and achievements, information his areas of interest and speciality, experience and training, and in some instances a statement of his philosophy of education. Such information will give the supervisor a "feel" for the school system and the staff.

Confer with Principals. The initial contact with a school should always be made through the principal, for his attitude will determine how effective the supervisor will be in that particular school. At the initial contact, the discussion should be kept more or less general, for the supervisor's aim should be to create a climate of acceptance and understanding.

Visit the School. To gain a panoramic view of a school and of its total program, the school should be visited. The supervisor will gain insight into the school situation--the climate, attitudes, relationships, and the degree of flexibility. When visiting a school, the supervisor should never hurry or give the appearance of being hurried. While this is true of all school visits, it is particularly true for the first one. On that visit, most teachers will make a judgment of the supervisor as a person.

Attend Faculty Meetings. If faculty meetings are attended, the supervisor gains some insights into the general professional level of the faculty, the type of concern discussed, the group process in action, and the role of the principal as the educational leader of his faculty. Faculty meetings and departmental meetings also provide an opportunity to explore some ideas for faculty reaction, to have the faculty suggest some areas of interest, and to discuss how the supervisor may be of greatest service to them. The last point will usually give the supervisor a clearer understanding of where he must begin.

Be Conversant with Other Services. The supervisor must become thoroughly conversant with other service groups. Depending on the size of the system, they may include the departments of curriculum, staff development, pupil personnel, instructional materials, reading services, special education, and other subject supervisors. The supervisor needs to know not only the services available, but be acquainted with the personnel offering the services.

Methods with Principals

A supervisor is generally responsible for providing services to principals and teachers, on a systemwide basis. While all services to all individuals are carried on concurrently in actual practice, it is nonetheless desirable to discuss them separately.

Services at the Systemwide Level

Aiding Principals in Their Operational Role. A supervisor coordinates the supervisory efforts of a school district to improve instruction. It is, therefore, incumbent on him to provide a means by which principals can clarify and re-acquaint themselves with their operational roles, and periodically evaluate those roles; to enhance the supervisor-principal team concept; to provide an opportunity for the demonstration of the value and effectiveness of problem-solving techniques, the group process, and decision-making; and to help to establish a good working relationship between supervisor and all principals in the district.

Capitalizing on Common Interests. The supervisor's potential service to teachers, individually and collectively, depends in large part on the principal's attitude and receptiveness to that service. Therefore, the supervisor should direct his initial efforts to the needs, concerns, and interests of principals.

Extending Perception of Learning. Another interest of the science supervisor is to extend the perception of both principals and teachers as to how pupils learn. Generally, the elementary principal is knowledgeable of the processes at the elementary level, but not at the secondary level. The converse is also true. The supervisor should instigate meetings to provide for communication. A supervisor can be a force in providing a climate in which change can take place, but he should realize that the desired change will take place in direct proportion to the encouragement and support provided by the principal.

Providing Leadership at the School Level

As the principal develops greater confidence in the supervisor, the latter has a greater opportunity to be of service in individual schools. The supervisor needs background information about the school, the faculty, and the students.

Learning About Pupils and Faculty. There are three areas that can provide the necessary information and experience regarding pupils, faculty, and what happens in the classrooms. Observations of classrooms: though there are exceptions, the best practice is generally for the principal and supervisor to observe classes together, over a period of time. During observations, both see the same things take place, and yet each perceives them in a different light. Discussion of the observations brings together varying points of view, and ultimately supervisor and principal can evolve a plan to improve instruction. Observations should generally be made at the invitation of the teacher. If the principal feels that joint observations will hinder rather than help in the ultimate goal, arrangements should be made for separate observations. Test results: a supervisor should also have some opportunity to examine the test results of the school, grade, or subject. This information provides him with information on (1) the relationship achievement to potential (for both student and school), (2) the level at which major instruction is directed (slow, average, high ability students, etc.), and (3) specific areas needing emphasis in order to secure a more even level of development. Report cards and grades: study grade distributions. These provide some indication of the point of view of the teacher toward students, learning, and subject matter. They give considerable insight into the teacher's "toughness" of attitude toward some artificial high equal standard for all students.

Methods with Teachers

Through earlier planning and working with principals, the supervisor has gained some rapport with the teachers in all schools and some insight into the operational level of the school and of the concerns and interests of the teachers. The supervisor should bear in mind that change is not produced in an individual in terms of the forces exerted upon him but in terms of how he perceives these forces. He cannot influence a teacher to improve or adjust his techniques or to gain deeper insights into different approaches and programs if that teacher's participation is not voluntary. To be service-oriented, the supervisor must present opportunities that the teacher considers desirable.

Services at the System Level

Consider Concerns and Desires of Faculties. A good way for a supervisor to ascertain the teacher's specific concerns and the areas he is most interested in studying and discussing is to establish an in-service committee to make recommendations. The committee should include representative teachers and principals who will meet with the supervisor. Ground rules for such meetings should include voluntary attendance, self-selection by members of the groups (grade level, subject level, interest level), and a principal or teacher leader. Additional guidelines might be set based on the establishment of a plan that will incorporate the teachers' interests and concerns. In addition, provision should be made for the self-selection of groups, subjects, or interest levels for discussion purposes; and for an outlet for "second guessing" or evaluation.

Help Teachers to Develop Strength in Stated Interests. In many, if not most, schools, there are teachers who are not only interested in a special field but have some special or additional training in that field. A supervisor can capitalize on this interest and extra training to help the district and its schools move forward through a planned approach.

For Involvement at the Individual School

Involve Teachers in Action Research. School faculties need to be encouraged to explore ideas and to try out these ideas without any stigma if they do not succeed. Not all plans work, but teachers need to feel secure and confident when they want to try out new ideas, practices, or techniques, for trying them out and evaluating progress is an integral part of an educational program.

A supervisor can give substantial support and guidance to a principal and his faculty in such ventures. In fact, he must do so. Here are some guidelines to aid in this type of planning: Teachers need an opportunity to think together. In order to do this, they need time. . . . For supervisors to be effective, teachers must be concerned with a problem of their own choosing. . . . The entire faculty need not explore the same problem or hypothesis. . . . As a supervisor works with teachers, he can be of service as a co-professional.

Demonstrate School Commitment. Commitment is a culmination of a number of factors--e.g., the professional climate in the school; the curiosity of the school faculty; the attitude of the teachers to the pupils; and the degree of freedom to explore, discuss, and evaluate as demonstrated and encouraged by the leadership of the school. In order to have a good program in a school, the faculty must be committed to a school commitment program not only in their own classroom programs, but on a schoolwide basis. Through his knowledge of the content of the subject matter or area that teachers may explore, a supervisor can play a much-needed role in developing the factors related to school commitment. Some guidelines include: Keep in touch with the developments of the program, yet do not try to direct them. . . . Have faith and confidence in the principal and the faculty who are trying to develop a program. . . . Know how to give the principal and faculty guidance and support, but know when and how to "get out of the way" . . . . Since the faculty needs to be totally involved, plan an active role in developing those factors that are necessary for the commitment of the total faculty to the program. . . . Take an active role in releasing the many related services in the school that are needed to implement the program.

Encourage Curriculum Evaluation and Improvement. There must be an on-going, continuous study and evaluation of the curriculum. Generally, this can be accomplished through greater articulation between departments. The development of an instructional advisory council will accomplish this purpose. The group should establish objectives to help in evaluating and improving the curriculum; these, in turn, should be discussed with the faculty. The council should work closely with the guidance department, administrative offices, and other resources personnel.

Assist in Understanding Students. Since many elements underlying methodology are quite basic to the purposes for teaching subject matter, the supervisor should be interested in methodology in the classroom as a means of improving instruction. And since the school is the agent of parents, emphasis needs to be placed upon a positive relationship between parents and the school. A supervisor can encourage such a relationship.

For Grade and Department Levels

To Improve Present Instructional Practices. Specifically, department chairmen are specialists in their subject field, as are also the teachers in the department. The supervisor has a salable commodity in all areas relating to the teaching and learning process, but he leaves the specific implementation of subject content to specialists of that content. One of the best ways for a supervisor to work with teachers to help them improve instructional practices is through an instructional council, similar to the one mentioned earlier. Discussion with such a group often leads to specific recommendations on matters that concern the faculty, such as: (1) teacher-oriented or constructed tests and their relationships to the teachers' stated objectives for the subject; (2) an evaluation of use of multisensory media, including their extent and diversity; (3) a review of the content of science courses and the sequence and understanding of the elementary and junior high school science programs; and (4) a familiarity with the content and organization of the mathematics and other departments as it relates to the teaching of the sciences.

To Use School Resources Better. Every school has resources that have not been tapped. Search the faculty for persons of varied experience--teachers who are interested in and have explored an avocation, have had extra study, have a special interest or training in a special area. A grade or department can draw upon these people. A supervisor should be sensitive to such resources and encourage their use.

To Initiate Something New. A more difficult function for the supervisor is to initiate something new. If this "something new" is based upon present practices and is the result of joint reevaluation in an atmosphere that encourages it, then the problem is not too difficult. Yet, it requires the full powers of the supervisor as an "insider" in the district, but yet an "outsider" in the grade level, department, or the school. A nonthreatening approach is the only one that will bear fruit.

To Meet Individual Needs

Guidelines for Classroom Observations. A supervisor is many times requested either by the principal or the teacher to visit the classroom. Their purposes may be entirely different. The problem of the supervisor is to determine what the real motives are, and also what to do when he is in the classroom. Teachers in general do not like supervisory visits because, when visiting classrooms, supervisors have too often been concerned with the activities of the teacher rather than with the learning of the pupils. Attention should be directed toward what happens to the pupils rather than what the teacher does.

(1) To study the materials the pupils are to learn, their validity for the objectives of education, their utility, interest, and value for the pupils, and their adaptation to the pupil's abilities and needs.
(2) To study the means used to stimulate and guide pupils' learning, the psychological principles used and their application to the specific learning to be acquired.
(3) To study the means used in discovering, diagnosing, and remedying the learning difficulties of pupils.
(4) To study the means used for evaluating the learning product, the nature and means of the methods of measurement, and their relation to the goals of the learning situation.

The supervisor should never forget that the basic purpose of the type of supervision indicated previously is to aid the teacher so that he will be better able to stimulate and guide the learning of his students. The supervisor should do everything possible to see that teachers understand these purposes. If they do, criticism of supervisory visits will diminish, and, hopefully, teachers will even request visits. One problem that is continuously evidenced is whether the classroom visitation should be announced or unannounced. The unannounced visit is generally less effective than either the announced visit or the one made at the invitation of the teacher. If a supervisor visits a classroom by invitation, the observation tends to be of the service and co-worker type. If he schedules himself, teachers will tend to relegate observations to the inspectorial type. Before a supervisor enters a classroom, he should:

. . .Establish a sound rapport with the teacher.

. . .If some recording of data is planned, the teacher should be fully cognizant of its nature, purpose and should have been involved in its development and the decision to use it.

. . .Be informed of the professional background and abilities of the teacher.

. . .Be informed of the abilities and background of the pupils in the class to be observed.

. . .Have clearly in mind the purpose of the visit. What the supervisor does in the classroom while he is observing is equally as important as his preparation for the visit.

. . .Enter the classroom before the classwork begins.

. . .Be as inconspicuous as possible.

. . .Do not interrupt the work of the class or take over instruction.

. . .If the class is involved in many activities where many groups are affected, move about in order to get a clearer concept of the work being accomplished.

. . .When the class period or observation is over, the supervisor should say some word of commendation to the teacher as he leaves.

. . .Make immediate arrangements with the teacher or the teacher and principal concerning the observation.

Helping the Inexperienced Teacher. The inexperienced teacher has many concerns of a very practical nature such as the content to be taught, discipline, and class management. Yet he has much to offer: knowledge of good practices, enthusiasm, definite ideas about what he wants to do, a philosophy of education, a desire for help and support and a willingness to seek it. A supervisor can be of service in providing opportunities for desired help. Guidelines include: monthly orientation sessions for new teachers, according to elementary and secondary levels, to discuss items of special concern to the teacher and supervisor; planned visits to the classroom of another teacher who has solved the same problems confronted by the new teacher; and joint planning of units with other teachers who are contemplating a similar unit.

The supervisor must assume that the teacher is well prepared and competent. Any other assumption will give his efforts a negative tone. A new teacher needs and desires support and encouragement. The supervisor needs empathy, patience, and understanding in order to provide positive help to the teacher.

Helping the Experienced Teacher. The major problem of a new teacher is generally classroom management and discipline. For the experienced teacher, the major problem is mainly one of encouraging him to move from one level of teaching to another. This is a higher level of professional improvement than is discipline. The experienced teacher who has recognized his needs or desires has generally broken through the conformity shell. Having expressed such needs or desires and having confidence in the ability of the supervisor, the teacher is willing to discuss, plan and help evaluate for a restructuring of an approach. Efforts to be of service to experienced teachers are perhaps most successful when the following guidelines are present: the teacher teaches in a school with an atmosphere conducive to evaluation and trial; the supervisor and teacher have faith in each other's knowledge, skill, and ability; and the supervisor does not "supervise" but works with the teacher as a co-professional.

Helping Teachers with Concerns. Teachers having difficulty in teaching a class generally do not seek help. Evidence of the problem may appear in (1) loss of control, (2) lack of student enthusiasm for the subject or activity, (3) considerable student absence or tardiness, or (4) general student apathy as suggested in the poor quality of work being done. The problem revolves around how to be of service and yet not injure the teacher's self-concept. Some theorists suggest that the classroom is the teacher's exclusive domain. It is not. The teacher is one person responsible for one facet of the broad program of education in the school. A supervisor should then not hesitate to offer some immediate help. Such help should be a continuation of that initiated by the principal, for the principal should have alerted the supervisor to the problem (if the supervisor had not yet visited the classroom). Two approaches are possible: (1) observe things that are wrong and tell the teacher about them and how to correct them; (2) emphasize things that are good and build on the teacher's strengths. There is no single approach to any teacher with problems. The supervisor, however, can be an excellent resource for the teacher if certain guidelines are considered: though the teacher is primarily responsible for the program in his classroom, a supervisor and principal also have a direct responsibility to the students to assure them adequate instruction in the content of a particular subject or in total programs of the classroom; any approach based on encouraging the strengths of the teacher will be more satisfying to the teacher and more lasting in terms of change; the supervisor works in the role of co-professional and not as an authority from the central office; the supervisor and principal continuously evaluate and re-evaluate the progress of their approach so that both will work as a team; encouragement and praise that is sincere is of utmost importance.

How to Evaluate the Program

Evaluation is basically a judgment-making process. Sound judgments require the collection, analysis, and coordination of different types of data from different sources. All the data should be used as a guide for improving the program. Evaluation is a means toward improvement, not a goal of the program. The nature and scope of the staff development will dictate the extent of evaluation.

Measure Outcomes of the Total Program. Measuring the effect of the total program means measuring the impact on the school system of all activities included within the framework of the organized program.

Reactions and Attitudes of Staff. The principal techniques for determining staff reactions and attitudes are surveys and personal interviews. Professional personnel react most favorably to the following activities: (1) Workshops in the summer and during the school year in which practical methods, techniques, and the use of materials and equipment are demonstrated and shared; (2) visits to other schools and classrooms; (3) on-the-job help from staff (or resource) people and consultants; (4) activities that increase participants' understanding of the group process for problem-solving; (5) activities in which participants study children and increase their understanding of how children learn and grow; (6) off-campus (within the school system) university courses in methods and content; (7) information-giving sessions with opportunity to exchange ideas and opinions; (8) supervising student teachers; (9) leadership training; (10) participating in action research; (11) curriculum development workshops; (12) attending conferences; (13) attending summer school; and (14) serving on advisory committees.

In general, the most effective activities are those that enable participants to recognize their own resulting growth. Planners must avoid at all costs monotony, repetition, and waste of time. In short, teachers in service have a right to expect that those guiding them will apply all that is known about the teaching-learning process.

Improvement of the Instructional Program. Study the results of standardized intelligence and achievement test of pupils in search of information on the quality and competency of teaching. Compare test results each year with those of the previous year (or years) to detect deviation and underachievement. If test results are not satisfactory and the causes are related to inadequate teaching, make plans immediately to provide appropriate in-service activities. School systems that send a high portion of their graduates to college usually study carefully the college records of their former students. And school systems that feature vocational training inquire about the work records of recent graduates who enter the so-called service industries.

Personnel Data. Investigate teacher turnover statistics and the reasons given for leaving. Study turnover data in terms of number of years of service, the subject taught, and the grade level. These may reveal clues to in-service needs. Do not underestimate the importance of the first year followup, for what happens during a teacher's first year is probably of more significance than the initial and brief orientation period.

Measure Outcomes of Individual Activities. To get a true evaluation of an in-service activity, base the evaluation (1) on actual observations of whether the participant's behavior has been altered as a result of the activity and (2) on the effect the changed behavior has on children and adults with whom he has contact. One of the best techniques for securing the desired information is the anecdotal record.

Measure Change in Behavior of Participants. Evaluate the effect of an in-service activity as positive when teachers put into classroom practice new concepts and skills acquired as a result of their participation.

Measure Effect in Classroom. To evaluate more fully the effectiveness of an activity, determine whether or not learning has been facilitated. Increased use of instructional materials by a teacher is of itself no guarantee that the learning situation for pupils has improved. Base conclusions on the classroom use of materials, on evidence of growth and learning on the part of pupils. Consider such factors as (1) how appropriate the material is to the content being taught and to the level and interests of the pupils; and (2) whether the teacher demonstrates a difference in skill as a result of the activity.

Consider Morale. Morale, a simple word but a difficult one to define, is certainly related to motivation, as the will to do--the desire to achieve bigger and better things, to be more competent, and to grow. Morale is not an end in itself, but a means of obtaining better results. If extraneous circumstances do not becloud the atmosphere, morale is generally high in a school system that provides (1) good working conditions under good administrators, (2) good salaries, and (3) good opportunities for professional growth and advancement. When evaluating in-service training activities and experiences as contributors to high morale, the following may be used as guidelines:

(1) Are the experiences cooperatively planned?
(2) Are decisions concerning program changes made cooperatively and on the basis of the most objective data possible?
(3) Does the group move forward toward common goals, achievement of goals, and group unity?
(4) Does the group feel free to ask assistance?
(5) Does the group feel encouraged to realize its potential?
(6) Are channels of communication established so that ideas can flow freely to the center of control and from it to every group and individual?
(7) Is both formal and informal communication recognized?
(8) Are the policies and procedures that serve as a framework for the operation of the schools readily available to total staff?
(9) Are several means established for two-way communication regarding interpretation and need for change of existing policies and procedures?

If the answer is "yes" in each case, then the in-service training program is playing a major role in contributing to high morale and the professional commitment and development of the school staff.

PREPARING THE SCIENCE BUDGET

Introduction

A budget is a financial estimate of the income and expenses of a particular operation. In practice, however, it is a specific vehicle indicating how monies will be spent. Except for emergencies, the budget indicates the maximum amount that may be spent for specific items.

The Board of Education has fiscal responsibility for spending money for a town's educational budget. Transfers from one account to another are usually done near the end of the fiscal year to balance the total money in the educational account. There may be a deficit in one account and a surplus in another and these transfers allow for a final accounting for the total dollar amount.

It is extremely difficult to estimate all expenses one year in advance. Price changes, inflation, voter referendums, and other variables make it almost impossible to predict each and every purchase needed. However, a systematic organization of expenditures will enable a department to anticipate and plan for most expenses. The following indicates two common methods for the determination of a science budget.

The Line-Item Budget

This is the most commonly used method of budget development in Connecticut. It has been in use in the state since the town fathers first set up an estimate of expenses for operating a school. Throughout the years various accounting improvements have taken place under the leadership of the State Department of Education and the U.S. Office of Education. Essentially, the many items of the budget have been classified and are recorded under the same heading and given a common budget account number. This allows comparison among the many towns within the state. A revision of the budget number system will be in effect for the 1975-76 education budgets in the state.

The Planning, Programming, Budgeting System (PPBS)

The PPBS method of planned spending is a method of detailing the resources needed to support a program based on the desired outcomes of the program. In essence, it is sufficiently detailed to yield a per-class cost factor over an extended period of years. A knowledge of the cost per year enables those with responsibility for the program to judge whether or not a program is worth the additional expense. It gives an additional parameter on which to judge an expenditure.

A PLANNING, PROGRAMMING BUDGETING SYSTEM

A number of school systems throughout the country are turning to Planning, Programming, and Budgeting Systems (PPBS), a systems analysis technique, as a management tool. In view of this interest, it behooves the alert science supervisor and science teacher to become more aware of and familiar with PPBS and each of its components. With this knowledge the science educator can play a more effective role in the decision-making process.

Many educational administrators are implementing PPBS for several major reasons. The reasons they give are: first, it can be a device for using total community resources more effectively; second, it is a more reliable frame of reference for intelligent decision-making; third, this system will enable the public to have a clearer accounting of pupil educational benefits gained from educational tax dollars spent; fourth, although PPBS is not a panacea, if it is used judiciously, it should move a school district forward as strengths within current learning programs are revealed and built upon and weaknesses corrected.

What Is PPBS?

PPBS is a multi-year plan based on carefully selected educational goals and objectives. These programs have been formerly thought of as the subjects to be studied in the curriculum. Budgeting is the business of detailing the resources necessary to support these programs and their anticipated accomplishments. PPB Systems match resources to objectives. The goal of PPBS is to provide a crystal-clear method for determining the quality and cost of what the educational system is producing as a means toward improving management of educational and fiscal resources.

Professor Harry J. Hartley, Dean of the School of Education at the University of Connecticut, states:

> "PPB Systems are intended to aid educators in:
> 1) identifying goals and defining objectives;
> 2) designing curricular programs to achieve objectives;
> 3) analyzing systematically the alternatives available;
> 4) providing decision makers with more and better data;
> 5) evaluating costs and effectiveness of programs;

6) extending the time in planning;
7) allocating budget dollars to instructional programs;
8) identifying program priorities;
9) promoting innovation programs and methods;
10) increasing public understanding of and support for the schools."

An Overview of the Process

PPBS is a participatory process which involves staff and community representatives in establishing goals and objectives and reviewing program accomplishments and budgeting for program continuation and improvement. It is an approach which concentrates on the outcomes of the learning process rather than on the process as an end in itself. Although this is a collaborative effort, the system recognizes the primary responsibility of the community to determine what the schools should accomplish and the primary responsibility of the staff to determine how the objectives should be accomplished.

The Components

The Planning Component

Planning is an extremely comprehensive and complex matter for the school system. It is built on the establishment of sound goals and detailed objectives, all of which must be related: (1) to what the school system wishes to accomplish, (2) to the evaluation process, and (3) to an effective identification and utilization of resources.

Planning embodies two subcomponents: instructional programs and the resources needed to support them. The planning procedure is appropriate for making policy decisions at every level. In addition, the planning component can be appropriate as a guide to measure the performance of staff and to pinpoint accountability. It can also help to promote human distinction and uniqueness without curbing self-definition of the creative young whom we serve.

The planning component permits a school district to decide what it really wants to accomplish, list alternative methods of reaching its goals, and then choose the path that is best in terms of time, effort, money, and other resources.

The Programming Component

Today with more complex educational programs and keen competition for tax dollars, administrators have difficulty pinpointing the exact cost of accommodating a student in each of the learning programs in which he is involved during the school year. Therefore, the program component requires that the money be allocated by learning program rather than by the traditional line-item method of accounting.

In traditional school accounting the expenditures are grouped by function; all administrative costs are lumped together; all instructional costs into a separate account, and so forth. In no way can the cost of a particular learning program be determined by allocating to it a certain portion of administrative costs, a share of instructional costs, and so on. As a result, individual costs of the various learning programs seldom are known and cannot readily be determined. Theoretically, by structuring the budget according to curriculum programs rather than by line-item basis this refinement can be made.

In so doing the administration can show the taxpayer and the board of education exactly what it costs to run quality learning programs. With respect to the program component, school boards will not be forced to consider recommendations for new school programs without supportive information on alternate programs, costs, and probable benefits.

The Budget Component

The budget is the grouping of all revenues and expenditures for a year. An educational budget is also a financial expression of the objectives, programs, and activities of a school system.

Up to now the budget has been prepared for the convenience of accountants rather than for educators or for the public. Because of this, the task of reporting program expenditures, requesting public funds, planning new programs, establishing priorities, evaluating performance, and describing program accomplishments to a tax-conscious public has not been done very well.

The learning program type budget is simply a more orderly reclassification of all proposed expenditures into classifications that are more meaningful to decision-makers. It restates all costs by programs. Thus, all the costs relating to teaching children to learn science, for instance, are identified uner the science learning program instead of being lost in a maze of details within such classifications as teachers' salaries, instructional materials, custodial staff, and so on.

Briefly, a budget prepared on the basis of programs provides the public with a visible expression of a community's values and socioeconomic philosophy. When focused on curricular programs, the budget should reveal exactly what a community does or does not care about in educating its most valuable resource--children.

Implications of PPBS

Those in favor of the PPBS approach list the following implications of its use.

For Administrators

Inasmuch as schools are expanding their services in response to increased demands and expectations, there has been a great upsurge in public interest in school programs, finance, and budgets. In this social climate educators require more powerful instruments to interpret their contributions and needs to the public and legislators. Systematic planning can provide educators with a more complete basis for decision-making.

Administrators view PPBS as:

(1) A way of coping with demands for more and better educational services. Such demands have placed tremendous burdens upon the schools, and PPBS may serve as the vehicle for transforming public demands into school programs.
(2) PPBS provides a framework for coping with the changes and responsibilities that will face the schools with increasing intensity year after year.
(3) PPBS will help to demonstrate to the community that school people are interested in performance and productivity, as well as product; and in the most efficient use of available, scarce community resources.
(4) PPBS helps schools to evaluate programs in terms of objectives, costs, and benefits.
(5) PPBS aids in the allocation of resources in terms of total needs.
(6) PPBS enables school people to appraise the performance of those responsible for reaching their stated goals.
(7) PPBS will provide a systematic means for considering and implementing innovations.
(8) It serves to answer many of the questions that citizens, public officials, and astute students are asking about public education.
(9) This streamlined use of resources will help in providing a framework for assessing how money is spent. It it not meant to replace judgment, but to provide a better factual basis for it.

For Science Supervisors

Superintendents, Boards of Education, and communities are asking more and harder questions before approving requests for science programs that have budgetary implications.

Thus, it is incumbent upon the science supervisor to develop with his staff those recommendations and proposals which answer such questions as:

1. Is the proposal within the constraints as set forth by the Superintendent and/or the Board of Education?
2. Is the proposal keyed to a specific system-wide or school-wide priority?
3. Does the proposal identify a specific need or problem?
4. Does the proposal identify a specific learning outcome and how and when this proposed improvement will be evaluated?
5. Does the proposal identify alternative ways to accomplish the improvement and list the advantages, disadvantages, and budgetary implications of each alternative?

PPBS provides the opportunity for the science supervisor to work cooperatively with his staff to think through, plan, and develop proposals directed towards one end--improved student learning.

For Science Teachers

Learning programs and curriculum are pretty much the same thing. The curriculum is all the experiences the learner has under the guidance of the school. It is that part of the individual's day for which the school has direct responsibility. It is simply a name for the organized pattern of the school's educational program. The curriculum encompasses the sum total of all the available planned and systematized interactions between learner and instructional system designed to lead to learning. The modern curriculum is focused on the learning rather than the teaching.

Three tasks are implied for the teacher once the broad educational goals and objectives have been clarified for each program. These tasks are to formulate instructional objectives; to harmonize with the educational philosophy of the total school program; to translate the learning program objectives into relevant learning experiences; to apply appropriate evaluation instruments to find out how well the expected behavioral outcomes of the objectives are realized.

PPBS and the Science Program Design

Learning Objectives

An individual in his personal life may have a goal to play par golf. This goal may be totally unachievable. It merely points out his intent and purpose. It is timeless. More specifically, however, he may make a New Year's resolution that by July 4 his average score of at least five rounds of golf played in accordance with PGA regulations will be less than 85. Now he has identified an observable terminal performance to be accomplished within a specific time period. It is an accomplishment directed toward his goal.

Similarly, goals and objectives can be established for the scope and sequence of a K-12 science program or any segment thereof.

Instructional objectives are the vital guideposts that direct the teacher and students along the learning pathway. Without them both might wind up somewhere else on their educational journey. Virgil Herrick states that:

> Without knowledge of the objectives of an educational program it is impossible to judge its adequacy. All evaluations of human behavior are made in terms of some definition of what is considered important to achieve. Objectives provide this definition and thus form a major basis for the appraisal of the educational development of children. This function is one of the important reasons for communities, teachers, and children to have available a statement of objectives to give direction to and appraise the value of the educational experiences children have in school. Evaluation, reporting, and promotion programs in the elementary school are dependent on the availability of a statement of objectives. Without objectives, such programs can only operate on expediency and on the basis of judgments whose educational bases are unknown. (8)

A well-written instructional objective should say three things: (1) what it is the student will be able to do when he has mastered the objective, (2) under what conditions he will be able to do it, and (3) to what extent he will be able to do it. Therefore, the teacher's instructional objectives must be clearly defined and stated in measurable behavioral outcomes terms. If this is done, the student can more easily see what he is trying to learn and it will be easier to relate the evaluation instruments to the instructional objectives.

Learning Experiences

The second task of the teacher is to select the most desirable learning experiences available to attain his objectives for each individual learner in the class. This involves methodology, media and materials, and utilization of community resources. In this way teacher and students can agree on what is to be accomplished. The learning environment should be related to the learning experiences. The creative teacher should structure the learning environment by setting up stimulating situations that will evoke the kind of behaviors that meet his objectives. In addition, the teacher must have some understanding of the kinds of interests and backgrounds of each individual child, his needs and achievements, in order to organize the experiences and environment in the most meaningful way for the individual learner. Emphasize the learning, not the teaching!

Evaluation

The third task of the teacher is evaluation. Evaluation is the comparison of the instructional objectives outcomes of a learning program with its measured accomplishments. The evaluation results will determine the relative success of the learning programs as compared to the predicted behavioral outcomes. The evaluation is valuable because it provides information on how to improve the learning program. It can even influence the setting of objectives. Evaluation provides the link to complete the planning component. Thus, by leading to the first step of setting objectives the cyclical nature of PPBS launches an ongoing decision framework.

A Science Program Analysis

The following is a sample of a program analysis developed by one staff-community team when this system opted to go the route of PPBS. It is not presented as something to be emulated or imitated. Rather, it may serve as a model which illustrates some of the major elements involved in such an analysis.

PROGRAM ANALYSIS

Science
Program Name

K-12
Level

I. Goal:

For each student to understand, appreciate and show interest in living things, the physical world, his environment, and his relationship to each.

Sub-goals: For each student to:

1) Understand and apply his knowledge of general concepts of science.

2) Demonstrate skills of inquiry (synonymous with scientific method, methods of science, processes of science and critical thinking.)

3) Demonstrate positive attitudes towards science and the environment.

4) Experience a feeling of satisfaction and enjoyment in learning science.

II. Objectives:

1. By the end of the second grade, 90% of the students will have achieved 90% of the objectives pertaining to the processes of science as specified in Science-A Process Approach and as measured by the Competency Measure of the American Academy for the Advancement of Science. (II)

2. At the end of each science unit in grades three through six, 75% of the students will have achieved 70% of the curricular objectives of that unit pertaining to their understanding of of the general concepts of science and skills of inquiry as measured by valid standardized and/or locally constructed tests. (I, II)

3. At the end of each secondary school level course in science, 75% of the students will have achieved 70% of the curricular objectives of that course pertaining to their understanding of the general concepts of science and their skills of inquiry as measured by valid standardized and/or locally constructed tests. (I, II)

4. At the end of each elementary school level year of secondary school level course in science, 90% of the students tested will have demonstrated positive attitudes towards science and the environment and will have experienced a feeling of satisfaction and enjoyment in learning science as measured by an

attitudinal inventory scale and student-teacher evaluation. (III, IV)

III. Program Description

Assumptions

1. There is no one fixed scope and sequence of a K-12 science learning program that is best for all students.
2. Students in the Greenwich Public Schools can learn science although they may learn in different ways and at different rates.
3. Student learning in science results from the interaction of a complexity of individual characteristics influenced by the family, the culture, the curriculum, the modes of instruction, and the organization and operation of the school.
4. The intellectual growth of students requires a curriculum with different kinds of learning components, taught through a rich array of instructional techniques, paced at a rate that assures individual mastery, and designed to bring each student to his maximum potential as a self-directed learner.

Scope:

Science instruction is available to all students in all grades. It is a mandatory course through grade eight. In order to graduate from the high school, a student is required to complete one year of science beyond the eighth year.

Elementary Schools

On the elementary school level, science is taught by the classroom teacher. In the primary grades, the program focuses primarily on the development of student skills of inquiry such as observing, classifying, measuring, and using space/time relationships. In the intermediate grades, students apply these skills of inquiry to further their understanding of the general concepts of life and physical science in such areas as Ecology, Oceanography, Embryology, Space, Electricity, Magnetism, Chemistry, and Rocks, Minerals and Fossils.

The recommended weekly time allotment for learning science is 100 minutes in grades K-2, 150 Minutes in Grade 3, and 200 minutes in Grades 4-6.

Junior High School

Beginning at grade 7, science is taught by teachers who have specialized training in science and science education. The Intermediate School Curriculum Science (ISCS), an individualized learning program in science, is to be piloted in some seventh grade classes in 1971-1972. Introductory Physical Science (IPS) is taught in the eighth grade to promote student understanding of the general concepts of physical science and to develop student skills of inquiry. In grade nine, science is elective. Biology (BSCS), Earth Science (ESCP), and General Science are offered for students of varying abilities and interests.

Classes in BSCS and ESCP meet for six periods per week; all other classes meet for five periods per week.

High School

Students may elect one or more of the following one-year courses: Biology: Biology I, and Advanced Biology; Chemistry: Fundamentals of Chemistry (Chem. Study), Descriptive Chemistry, and Advanced Chemistry; Physics: Physics I (Modern Physics) PSSC Physics (Physical Science Study Committee), ECCP (Engineering Concepts Curriculum Project) and Advanced Physics. Electricity and Electronics are offered for students of the Industrial Arts. Biological Oceanography is a one-semester course.

All high school science courses are taught for at least six periods (12 mods) per week.

IV. Constraints:

Elementary School Level

1. The median number of semester hours in science completed by elementary school teachers is six.
2. In the primary grades, significantly less time is devoted to classroom instruction in science than is recommended.
3. Improved facilities are needed for efficient production of locally developed curricular materials designed for individual student learning.

Secondary School Level

1. No science laboratory assistants are on the staffs of the junior high schools.
2. All physics and chemistry teachers teach five classes, each of which meets for at least 6 periods (12 mods) per week.

V. Evaluation

Evaluation of learning outcomes will be determined through the use of standardized and locally constructed tests which are valid for the science program. Additionally, student reactions to the science program will be elicited through appropriate student attitudinal and interest surveys.

Some of the standardized tests that may be used in the evaluation program at the various levels include the following:

Elementary School Level

- American Academy for the Advancement of Science Competency Measure
- Stanford Achievement Test, Science

Secondary School Level

- Nelson Biology Test
- Cooperative Science Tests
- American Chemical Society Test
- Dubins Earth Science Test
- Scientific Attitude Inventory

Most budgets consist of a continuation budget which is designed to maintain ongoing programs, and program improvement budgets which provide for additions to the current program.

The Continuation Budget

Its Nature

An efficient budget process is one which requires an identification of goals and objectives and then a specification of the resources needed to achieve these objectives. Towards this end as well as to simplify and reduce the budget workloads, the budget-building process may be divided into two portions: program continuation and program improvement. Essentially, the program continuation portion consists of an identification of the financial resources required to maintain existing programs at current levels for the year.

The Criteria

If the continuation budget is designed to maintain current programs at current levels of achievement, then it is essential to assess the budgetary impact of the following:

1. Student enrollment--either increases or decreases.
2. Attrition--consumption, obsolescence, etc., of supplies and equipment; i.e., what new and/or replacement items are needed to maintain the program at the current levels of achievement?
3. Previously approved program improvements--i.e., what improvements had been previously approved that have carry-over budgetary implications?

The Program Improvement Budget

Its Nature

Program improvements are those proposals which support system-wide priorities and are designed to improve the degree to which the program objectives are achieved.

Program improvement proposals should contain the following:

1. Outcomes

   It is essential that a proposed program improvement be described in terms which specify what the improvement will accomplish rather than how it will be accomplished. Its basic aim is to accomplish better the goals and objectives of a program.

2. Alternatives

Alternative ways to accomplish program improvement are intended to describe how the same degree of improvement can be accomplished in different ways. It is particularly important to keep in mind that differences in degree of accomplishment do not constitute acceptable alternatives because they do not meet the basic criterion of accomplishing the same program improvement. Furthermore, each alternative listed must be viable, i.e., one that the writer is willing to live with. The long-term and short-term advantages and disadvantages should be considered for each alternative.

3. Multi-year Projection

Five-year financial projections for program improvements make clearer than ever before the multi-year financial implications in the final approval and acceptance of every program improvement.

Review Procedures

It is advisable that the staff know in advance the review procedures that will be used in judging the acceptability of program improvement proposals. Some suggested criteria questions may consist of the following:

1. Is a significant problem or need addressed?
2. Do the benefits of the improvement further the program goals and objectives?
3. Are alternatives identified which specify different ways to accomplish the same degree of improvement?
4. Has each alternative been thought through, taking into consideration long-term as well as short-term advantages and disadvantages?
5. Are the financial projections all-inclusive and accurately identified?

A Sample Program Improvement Proposal

The following is a sample of a science program improvement proposal developed cooperatively by three physics teachers and submitted to central administration for their review and consideration. Again, this is presented for illustrative purposes only.

PROPOSAL FOR PROGRAM IMPROVEMENT

SCIENCE
(Program)

SCIENCE - 1
(Improvement #)

GREENWICH HIGH SCHOOL
(Location(s))

J.C WESNEY	6/19/73	MR. J. BIRD	DR. MURRAY STOCK
(Proposed by)	(Date)	(Principal(s)	(Coordinator)

PROBLEM/NEED DEFINITION - Explain the Specific Need or Problem Requiring the Improvement
Corresponding to the previously stated and continuing Board of Education goal to develop and implement individualized science programs at GHS. There is a need to provide for the development, pilot use, revision, and eventual full-scale implementation of individualized content and career-related programs in physics.

IMPROVEMENT DESCRIPTION - Explain What the Explicit Outcomes of the Improvement Will be Rather Than How It Will be Accomplished. Describe the Degree of Improvement Related to Program Objectives and How and When It Will Be Evaluated.
For the anticipated 400 physics students, this improvement will: 1) provide for more students to be able to work at their own pace and, to a much greater extent, to adapt the course content and materials to their needs and capabilities; 2) improve student understanding and knowledge of career opportunities in the science and technology areas related to physics; 3) improve achievement in student cognitive understanding and skill capabilities in physics; 4) improve student's affective response to their experience in studying physics. (over)

ALTERNATIVES - List Ways How To Accomplish the Improvement, In Priority Order. Describe Real Alternatives, Not Differences In Degree or Timing.

	NET COST TO OPERATE IMPROVEMENT FOR EACH YEAR					
	1974-75	1975-76	1976-77	1977-78	1978-79	
A. Develop first generation instructional units during the summer of 1974, pilot test the units during 1974-75, revise during summer of 1975, introduce full-scale program during 1975-76, carry out final revision during summer of 1976, introduce final version during 1976-77	$3487	$2187	$1387	$500	$500	X
B. During 1974-75 search for, select and purchase existing individualized physics study materials from programs being used elsewhere in sufficient quantity for use by pilot testing group of four classes during 1975-76. Alter and revise program during summer of 1976 and introduce revised program on full-scale basis during 1976-77, conduct final revision during summer of 1977 and introduce final version during 1977-78.	$5500	$2387	$1187	$500	$500	
C. Same essential development scheme as outlined in either A or B above but with development work being conducted during the academic year through the use of substitutes for released staff time of about 1 week per quarter for two-member development teams.	$3400	$2100	$1300	$500	$500	X

EXPLANATION OF ALTERNATIVE

June 19, 1973

SCIENCE
(Program)

GREENWICH HIGH SCHOOL
(Location)

ALTERNATIVE A TO PROGRAM IMPROVEMENT NUMBER SCIENCE -1

NET COST TO OPERATE IMPROVEMENT FOR EACH YEAR

Dept.	Obj.	Object Classification	1974-75	1975-76	1976-77	1977-78	1978-79
		- PERSONAL SERVICES Regular Salaries					
620	106	Teachers	$ 2487	$ 1287	$ 687	-	-
		- SERVICES - OTHER THAN PERSONNEL					
		- SUPPLIES AND MATERIALS					
620	310	Teaching Supplies	$ 500	$ 500	$ 500	$ 500	$ 500
620	311	Textbooks	500	400	200	-	-
		- MAINTENANCE					
		- EQUIPMENT AND IMPROVEMENTS					
		OTHER					
		TOTAL..........	$ 3487	$ 2187	$ 1387	$ 500	$ 500

ADVANTAGES - 1) This would permit the development of a "tailor-made" individualized physics program suited to the student population, community and departmental resources of GHS. 2) Provides for the major development and revision efforts during the summer when attention of the faculty would not be taken from their instructional programs and students. 3) Provides for a period of intense, continuous developmental effort. 4) Enables the materials and strategies to be closely related to the PPBS goals and objectives for physics being developed during 1973-74 and 1974-75. 5) Permits the use of features from more than one successful individualized physics program as models for the development.

DISADVANTAGES - Would require the availability of faculty members during the summer.

EXPLANATION OF ALTERNATIVE

June 19, 1973

SCIENCE
(Program)

GREENWICH HIGH SCHOOL
(Location)

ALTERNATIVE B TO PROGRAM IMPROVEMENT NUMBER SCIENCE-1

NET COST TO OPERATE IMPROVEMENT FOR EACH YEAR

Dept.	Obj.	Object Classification	1974-75	1975-76	1976-77	1977-78	1978-79	
		- PERSONAL SERVICES						
620	106	Regular Salaries-Teachers	$ 400	$ 1887	$ 687	-	-	
		- SERVICES - OTHER THAN PERSONNEL						
		- SUPPLIES AND MATERIALS						
620	310	Teaching Supplies	$ 100	$ 500	$ 500	$ 500	$ 500	X
620	311	Textbooks	5000	-	-	-	-	
		- MAINTENANCE						
		- EQUIPMENT AND IMPROVEMENTS						
		OTHER						
		TOTAL	$ 5500	$ 2387	$ 1187	$ 500	$ 500	X

ADVANTAGES - 1) Would eliminate the need for the major task of initial development being carried out locally. 2) Would require careful examination of several successful individualized programs from throughout the country.

DISADVANTAGES - 1) Would not reflect the local characteristics of students, school and community in the initial version of the materials. 2) Would not necessarily reflect the goals and objectives of the GHS Physics Program.

EXPLANATION OF ALTERNATIVE

June 19, 1973

SCIENCE
(Program)

GREENWICH HIGH SCHOOL
(Location)

ALTERNATIVE C TO PROGRAM IMPROVEMENT NUMBER SCIENCE-1

NET COST TO OPERATE IMPROVEMENT FOR EACH YEAR

Dept.	Obj.	Object Classification	1974-75	1975-76	1976-77	1977-78	1978-79
		- PERSONAL SERVICES					
		Regular Salaries					
620	106	Teachers	$ 2400	$ 1200	$ 600	-	-
		- SERVICES - OTHER THAN PERSONNEL					
		- SURPLIES AND MATERIALS					
620	310	Teaching Supplies	$ 500	$ 500	$ 500	$ 500	$ 500
620	311	Textbooks	500	400	200	-	-
		- MAINTENANCE					
		- EQUIPMENT AND IMPROVEMENTS					
		OTHER					
		TOTAL.........	$ 3400	$ 2100	$ 1300	$ 500	$ 500

ADVANTAGES - 1) Would provide for development during the academic year when all faculty members are available. 2) Would include the advantage of local development sited for Alternative A.

DISADVANTAGES - 1) Would take teacher's time and attention away from their students and instructional program. 2) The use of substitutes would not provide the continuity nor a sound program during the times of development. 3) Would provide shorter, intermittent development periods rather than the more effective, continuous, intensive development period.

Evaluation of these outcomes will be reflected in improvement in scores on exams and responses to questionnaires developed in conjunction with the PPBS goals and objectives for physics. These instruments will include semester and year-end student attitude surveys, a semester exam, and a final one.

A Concluding Thought

Planning, Programming and Budgeting Systems hold much for the future in education in general and the science supervisor and science teacher in particular. It can be the tool of the teacher as well as the administrator in evaluating learning programs and assessing performance. Results of this evaluation can provide the innovative science supervisor with the basis for further decisions or alternate choices regarding his instructional objectives, planned learning experiences, environmental stimulation, evaluation, and feedback.

PPBS is one means of involving school personnel in policy formulation, curricular program design, and long-term planning. PPBS offers a well-planned systems approach to curriculum. The curriculum realities of now and of the future make it imperative to gear up to utilizing all that is known about the curriculum in producing educational programs that will meet the high expectations set for the public schools.

Glossary of PPBS Terms

CONSTRAINT. A constraint is an external condition which limits the degree to which program objectives can be achieved. The constraints may be of a financial, physical, timing, policy, statutory, strategic, or political nature.

GOAL. A goal is a statement of broad direction, purpose, or intent based on the identified needs of the community. A goal is general and timeless; that is, it is not concerned with a specific achievement within a specified time period.

MULTI-YEAR FINANCIAL PLAN. The Multi-year Financial Plans (MYFP) present financial data for existing and alternative programs projected for a period of several years.

OBJECTIVE. An objective is a desired accomplishment which will advance the program and the system toward a corresponding goal. The objective statement must include the evaluative criteria to be used in measuring accomplishment within a given time frame. The degree of accomplishment established for the objective must be realistic in light of the constraints.

PERFORMANCE OBJECTIVE. A performance objective is a statement of intended learning outcomes and includes the following:

1. specification of *who* is going to perform the behavior,
2. specification of the observable terminal behavior, i.e., a description of what the successful learner is able to do at the end of a specific time period,
3. specification of the criterion, standard, or proficiency level to be accomplished by the learner,
4. the time needed to accomplish the desired behavior, and
5. the method by which the behavior will be evaluated.

PROGRAM. A program is defined as a group of interdependent, closely related services or activities progressing toward or contributing to a common goal and set of allied objectives.

PROGRAM BUDGET. The program budget in a PPBS is a statement of policy that relates cost to goals, objectives, and programs based upon a program structure classification. When the goals and objectives of a school district have been defined and the programs to meet these objectives have been documented, the estimated costs of these programs must be reported in the program budget.

PROGRAM CODES. Programs are coded by number to facilitate the collection of program data costs and statistics in a format consistent with the program structure.

PROGRAM CONTINUATION. The costs required to maintain an existing program at current levels of achievement. Changes in costs would normally result only from increased or decreased enrollment, wear, previous program changes, or a change in the mix of resources.

PROGRAM COORDINATOR. This term is applied to those persons who have Central Office positions of staff responsibility for system-wide program design.

PROGRAM DIRECTOR. This term is applied to those persons in the Central Office position of Director or Assistant Superintendent to whom principals and coordinators have the supervisory line responsibility for the design and/or implementation of each program.

PROGRAM IMPROVEMENT. A proposal which would improve the degree to which the program objectives are achieved, or, in the case of support programs, the level at which support is provided.

PROGRAM LEADERS. A general term applied to staff members, below the level of director, who have responsibilities for program design or implementation. It is commonly applied to coordinators, principals, headmasters, assistant principals/housemasters, division chairmen (GHS), senior teachers, and teacher leaders.

PROGRAM MANAGERS. This term is applied in a general way to persons who have day-to-day, operational responsibility for program implementation, such as building principals, the special education and research and evaluation coordinators, the cafeteria supervisor, and the chief plant engineer. These persons have the primary responsibility for administering the approved budget.

PROGRAM STATEMENT. The program statement is a formal document outlining program goals, objectives, description, constraints, and evaluation.

PROGRAM STRUCTURE. A program structure is a hierarchical arrangement of programs which displays the relationship of activities to goals and objectives. The structure contains categories of activities with common output objectives.

PROGRAM TEAM. A representative group of citizens and staff members responsible for the development of a PPBS program analysis document within a given discipline or department.

LINE ITEM BUDGETING PROCEDURES

Many districts in the state are moving toward a PPBS budgeting system. Approximately 50 towns are now operating with PPBS. Other towns utilize the Line-Item Budgeting System. In this system, each major item in a budget is given a number to indicate the area of the expenditure, and sub-numbers are used to indicate the department or more specific area in the budget.

For 1975-76 a revised system of accounting numbers will be used statewide for reporting of budget items. The major divisions for this system are given below.

Expenditure Account Number	Category
1000 Series	Instruction
1100	General Learning
2000 Series	Instructional Supportive Programs
2100	Pupil Services
2200	School Libraries and A.V. Materials
2300	General Administration
2400	School Administration
2500	Business Management Services
2600	Other Supportive Services
2900	Student Body Activities
3000 Series	Community Services
4000 Series	Outgoing Transfer Accounts

It is beyond the scope of this section to include the many details in setting up the budget showing the complete expenditure accounts function codes. The inclusion of these numbers is for illustrative purposes only. The pertinent codes which might be utilized in a science budget are given in detail in the following example.

The dollar figures are included for illustration only. They are approximate figures for a 9-12 grade secondary school having a student population of approximately 1750 and a teaching staff of approximately 100. The figures are for the proposed 1975-76 budget. The reader should not misconstrue these figures as being desirable or undesirable, since a simple comparison is not possible. Much greater detail would have to be given in order to evaluate the expenditures.

In science, the following areas are of major importance in the determination of a yearly budget. Only the general account number is given, usually 7 digits, although other 3 digit sequences followed by a 2 digit sequence are utilized to indicate the school and the department respectively.

Account Number	Category	Expense
1100.332	Professional Meeting Expenses There are numerous conferences pertaining to science teaching conducted each year by NSTA, CSTA, NEACT and many others. It is desirable that some members of the department get to these conferences to exchange ideas, and keep aware of new materials and techniques.	$500.00
1100.410	Science Supplies This is the major area of science equipment and supplies and would include such things as chemicals, glassware, and all other expendables in the science budget.	$8000.00
1100.420	Textbooks This includes textbooks, lab manuals, and usually limited amounts of A.V. software.	$4020.00
2220.410	Library and A.V. Services Included here would be rental or purchase of films for science and materials for Overhead or other projector equipment. Also, video tape and other software and hardware. Library materials should be selected by the library staff after consultation with the science staff to obtain desirable volumes.	$1200.00
2540.3232	Science Equipment Repair Microscopes, pH meters, spectrophotometers, and all other pieces of equipment should be kept in good repair. Annuals maintenance should be done on all equipment. Some major items, such as a Planetarium, may be under a separate maintenance contract.	$720.00
2540.5401	Capital Outlay-Science This area is for non-expendable equipment. They are mainly non-recurring expenses. Most pieces of apparatus or equipment for demonstration uses, or equipment of a specialized nature for new courses would be found in this section of the budget.	$1300.00
2540.5402	Replacement of Equipment Some science equipment has a limited life or becomes obsolete for various reasons. Plan ahead to replace these items periodically.	$500.00

2550.3314 Field Trips $500.00

The money in this account was specifically for a Field Course meeting afternoons. Other field trips may be included depending on the policy of the town.

There should be some provision for a petty cash account for the science department. Throughout the year numerous items from animal food to zither strings must be purchased locally. The amount will vary depending on the size of the school and the number and kind of laboratory activities carried on. This money should be earmarked as part of the 1100.410 account.

In the determination of a science budget there are numerous factors which must be considered. Each town has its own method of arriving at a total dollar figure for the science budget. Some towns have utilized a per-pupil grant for allocating the science budget, but this is an oversimplification of a complex task, and many items must be considered in arriving at a fair dollar figure.

Factors To Consider In Arriving at A Science Budget Figure.

1. How many different courses are offered in the science department?
2. How many sections of each course will be offered?
3. What is the number of students in each subject level?
4. What is the total student enrollment in the science department?
5. How many teachers are in the department?
6. How many classes per day are taught by each member of the department?
7. Are Advanced Placement Courses taught? How many?
8. How many textbooks are needed? Consider replacements or rebinding, new course, expendable lab manuals, etc.
9. Are any new courses being offered? Consider initial "start-up" costs for equipment and materials.
10. What curricular revisions have taken place? Is more laboratory time anticipated, or have any experiments been added or deleted that will change the cost of operating such a course?
11. How have the prices of science supplies and equipment changed in the past year? Science supplies and equipment increased by approximately 35 per cent in 1973-74.
12. What is the effect of dropping enrollment in the school

on the overall science budget?

13. Do you have sufficient funds available to acquire A.V. software for the department?

14. How many laboratory periods per week are available?

PLANNING THE SCIENCE BUDGET

Planning a budget is a continuing process and the following outline is merely suggestive of what steps might take place during the school year.

September - Most of this month will be devoted to checking on incoming supplies, books, and other materials.. Shortages of texts because of overloads, balancing of classes, and taking care of changes in student programs.

October - Review of science curriculum with particular attention to student needs. Sub-committees on curriculum development should be in operation. Teachers (or laboratory aides) should be reporting on shortages, or desired changes in sections, etc.

November - By the end of this month there should be some clear direction to indicate needed changes in the department. New courses or other curriculum changes should be clearly defined at this time.

December - Preliminary budget figures should be proposed based on all available evidence at this time.

January - Review of new course proposals and budget implications should be fairly will firmed up at this time. Moving into the second semester should enable the department to pinpoint shortages and needs for various materials.

February - Revision of science curriculum offerings to be incorporated into student curriculum guide.

March - Orientation and guidance of students in course selection for the following year.

April - Registration of students for sourses for the following year. Set up teaching schedules and course sections based on these data. Revise budget figures if necessary, based on actual registration.

May - Confirmation of student and teacher schedules. Town budgets probably up for elector approval through the representative government.

June - Revision of budgets, curriculum offerings and other items based on actual money available for the department. Prepare orders, complete inventories and evaluate the work of the department for the past year.

BUDGETS AND PUBLIC CONCERN

At present we are beginning to see a drop in enrollments at the elementary and junior high school levels. This trend will continue into the high school in the next few years and will have an effect on the school budget.

It is necessary to provide to the public as much information as possible about the basic factors which affect the quality of education so that future decisions can be made on the basis of common information. Program changes call for a detailed analysis of the added worth of the program to the quality of the instructional program.

SCHOOL TIME SCHEDULES

In the comprehensive high school of the 70's, the student has a wide choice of courses, both required and elective, in his high school program. In addition, work-study, advanced placement, alternate school, personalized curriculum, and other programs all affect the selection of a time block schedule for the school. Where a school has a well defined philosophy or written educational objectives the choice of a suitable time block schedule must be based on the priorities of the school system. Each time block schedule has certain advantages and disadvantages and the final selection is usually a compromise to enable the school program to have flexibility and variation to meet the needs of most of the students.

The trend away from the traditional fixed, unvarying time block schedule started in the 50's. Many nationally developed curriculum revision programs pointed to the need for more time in the curriculum for laboratory oriented science programs. In many other areas of the school program the desire for variable time schedules became evident as experiments in team teaching, open classroom, and other modes of teaching forced changes in the traditional schedule.

The actual school day in Connecticut High Schools is typically from 8:00 A.M. to approximately 2:15 P.M. There is actually very little variation from this schedule which is dictated by bus schedules, varsity sports programs, and tradition. Of this 6 hours and 15 minutes, the lunch program, home room, and passing from class to class accounts for 60 to 80 minutes of the school day. This leaves approximately 300 minutes for actual class time.

The traditional 16 Carnegie Units needed for graduation in the 40's no longer holds true today. Most high schools in the state require more than 16 credits for graduation in the four year program. Many students have 5 or 6 courses plus physical education and this has led to a variation in the school schedule to allow the students to select a comprehensive program of studies. School schedules having 5, 6, 7, or 8 periods per day are quite common. Rotation of classes, variable time blocks, various cycles of time are all utilized to give the student the maximum selection of courses during his school program.

It is beyond the scope of this booklet to go into great detail on the many types of schedules in operation in the secondary schools throughout the country. Some of the more common schedules and variations are described and illustrated.

TRADITIONAL SCHEDULE - The traditional type schedule is characterized by a fixed number of time blocks of the same length, meeting at the same time each day for five days a week.

VARIABLE TIME BLOCKS - Similar to the traditional schedule except that the classes vary in length of time. Allows greater flexibility for laboratory work and other activities. See Sample 1.

VARIABLE TIME BLOCK-SIX PERIOD DAY - Dropping one or more time blocks per day allows for lengthening the remaining blocks. Classes may meet only four times per week. See Sample 2

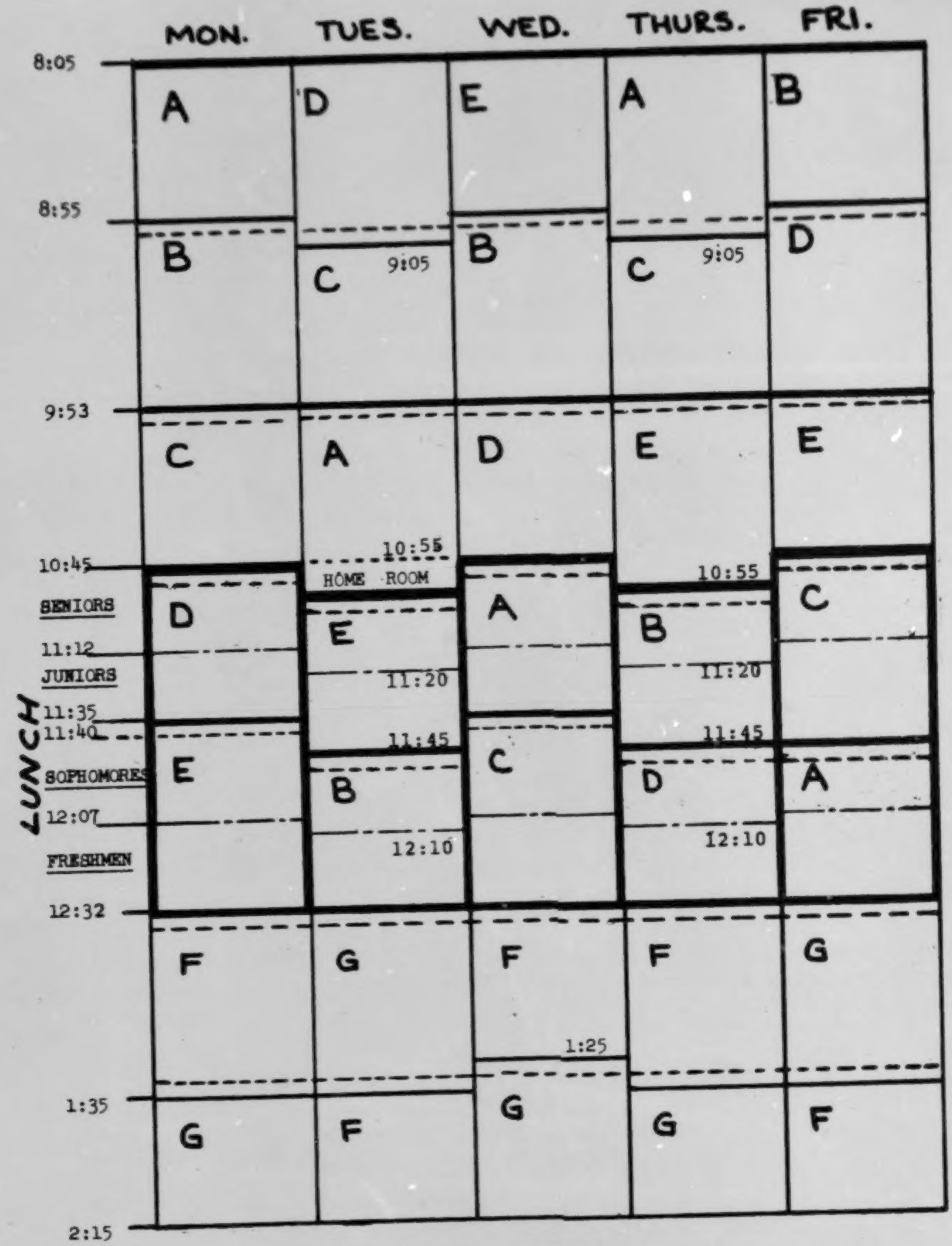
VARIABLE TIME BLOCK-ROTATION-EIGHT DAY CYCLE The rotation allows a fixed time block during the day with variable length periods. The rotation moves each class into the different period lengths. The eight day cycle allows each class to meet 7 times during the cycle. Note alternate schedule for assemblies. See Sample 3

FIXED TIME BLOCK-ROTATION-SEVEN DAY CYCLE - The fixed length of periods can be modified by the use of the X period. In each week, the X period follows a different class. Use of double periods or the X period could extend class time for labs and other uses. Also, note alternate assembly time schedule. See Sample 4

SEMI-ROTATION-FIVE OR SIX PERIOD DAY - Each class meets 4 times per week. Variable class length for varying activities. See Sample 5

MODULAR SCHEDULING - In modular scheduling, the school day is broken down into stripes or mods of 10 to 15 minutes each. A class may meet for varying mods during any day. Or, a student may be given more or less mods in a particular class depending on his needs in that subject. The possible variations are so great that usually the schedule is computerized.

Many schedules that purport to be mod schedules are in reality a variation of one of the samples shown. Modular scheduling has almost unlimited variations to meet the needs of the students. In theory, the modular schedule is an individualized schedule designed for a particular student, taking into account the complete educational experiences of the student, and the abilities and needs of that student.


MON.
TUES.
WED.
THURS.
FRI.
8:05
8:55
9:53
10:45
SENIORS
11:12
JUNIORS
11:35
11:40
SOPHOMORES
12:07
FRESHMEN
12:32
1:35
2:15
LUNCH
A
D
E
A
B
B
C
9:05
B
C
9:05
D
C
A
D
E
E
10:55
HOME ROOM
10:55
D
E
A
B
C
11:20
11:20
11:45
11:45
E
B
C
D
A
12:10
12:10
F
G
F
F
G
1:25
G
F
G
G
F

SAMPLE 1 - VARIABLE TIME BLOCKS, SEVEN PERIOD DAY

NEW CANAAN HIGH SCHOOL, NEW CANAAN, CONNECTICUT

1974-1975

NAME________________________________CLASS OF____________

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8:15- 8:58	A	G	F	E	B
8:58- 9:03		ATTENDANCE PERIOD			
9:06-10:09	B	A	G	F	E
10:12-10:55	C	C	C	C	C
10:58-11:19	D 1		D		D
11:19-11:40	2				
11:40-12:01	3				
12:01-12:22	4				
12:25- 1:29	E	B	A	G	F
1:32- 2:15	F	E	B	A	G

SAMPLE 2 - VARIABLE TIME BLOCKS, SIX PERIOD DAY

WESTON HIGH SCHOOL, WESTON, CONNECTICUT

Regular Class Time	Wednesday and Assembly Day Class Time	TIME SLOTS	DAILY ORDER OF PERIODS							
			A	B	C	D	E	F	G	H
7:50 - 8:05	7:50 - 8:05	HOMEROOM								
8:10 - 8:55	8:10 - 8:45	(1)	1	8	7	6	5	4	3	2
9:00 - 9:50	8:50 - 9:30	(2)	2	1	8	7	6	5	4	3
9:55 - 10:45	9:35 - 10:15	(3)	3	2	1	8	7	6	5	4
10:50 - 12:00	10:20 - 11:00	(4)	4	3	2	1	8	7	6	5
10:50 - 11:10 11:15 - 11:35 11:40 - 12:00	(Lunch Times: Regular Schedule)									
12:05 - 12:50	11:05 - 12:15	(5)	5	4	3	2	1	8	7	6
	11:05 - 12:15 11:30 - 11:50 11:55 - 12:15	(Lunch Times: Assembly Schedule)								
12:55 - 1:45	12:20 - 1:00	(6)	6	5	4	3	2	1	8	7
1:50 - 2:35	1:05 - 1:45	(7)	7	6	5	4	3	2	1	8
	1:50 - 2:35	(X)								

PERIODS

SAMPLE 3 - ROTATION, SEVEN PERIOD DAY, EIGHT DAY CYCLE

DARIEN HIGH SCHOOL, DARIEN, CONNECTICUT

	I					II					III					IV					V					VI					VII					
HR	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	7:45 7:55
1	1	7	6	5	3	2	1	7	6	4	3	2	1	7	5	4	3	2	1	6	5	4	3	2	7	6	5	4	3	1	7	6	5	4	2	8:00 8:50
2	2	1	7	6	4	3	2	1	7	5	4	3	2	1	6	5	4	3	2	7	6	5	4	3	1	7	6	5	4	2	1	7	6	5	3	8:55 9:45
3	3	2	1	7	5	4	3	2	1	6	5	4	3	2	7	6	5	4	3	1	7	6	5	4	2	1	7	6	5	3	2	1	7	6	4	9:50 10:40
4	4	3	2	1	6	5	4	3	2	7	6	5	4	3	1	7	6	5	4	2	1	7	6	5	3	2	1	7	6	4	3	2	1	7	5	10:40 12:20
5	5	4	3	2	7	6	5	4	3	1	7	6	5	4	2	1	7	6	5	3	2	1	7	6	4	3	2	1	7	5	4	3	2	1	6	12:25 1:12
6	6	5	4	X	1	7	6	5	X	2	1	7	6	X	3	2	1	7	X	4	3	2	1	X	5	4	3	2	X	6	5	4	3	X	7	1:17 2:05

6 Period Day
LUNCH SCHEDULE
10:40-11:05 1st
11:05 11:30 2nd
11:30-11:55 3rd
11:55-12.20 4th
7 Period Day
10:58-11:23 1st
11:23-11:48 2nd
11.48-12:13 3rd
12.13-12:38 4th

7 Period Day
7:45- 7:55
8:00- 8:40
8:45- 9:27
9:32-10:12
10:17-10:58
10:58-12:38 Lunch
12:43- 1:22
1:27- 2:05

Long Assembly
1st Time Block
7:45- 7:55
8:00- 8:51 Assembly
8:56- 9:35
9:40-10:19
10:24-11:03
11:03-12:43 Lunch
12:48- 1:24
1:29- 2:05

Long Assembly
4th Time Block
7:45- 7:55
8:00- 8:39
8:44- 9:23
9:28-10:07
10:12-11:03 Assembly
11:03-12:43 Lunch
12:48- 1:24
1:29- 2:05

SAMPLE 4 - ROTATION, SIX PERIOD DAY, SEVEN DAY CYCLE

ROGER LUDLOWE HIGH SCHOOL, FAIRFIELD, CONNECTICUT

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
D 7:50-8:40	B 7:50-9:00	A 7:50-8:35	C 7:50-9:00	F 7:50-8:40
B 8:45-9:35	H.R. 9:05-9:15	H.R. 8:40-8:50	H.R. 9:05-9:15	C 8:45-9:35
A 9:40-10:30	A 9:20-10:30	B 8:55-9:40	D 9:20-10:30	D 9:40-10:30
		C 9:45-10:30		
F 10:35-12:07	C 10:35-12:07	D 10:35-12:07	A 10:35-12:07	B 10:35-12:07
G 12:12-1:15	G 12:12-12:57	E 12:12-1:15	E 12:12-12:57	E 12:12-1:15
E 1:20-2:05	F 1:02-2:05	F 1:20-2:05	G 1:02-2:05	G 1:20-2:05

1st Lunch
Lunch 10:30-10:55
Class 10:59-12:07

2nd Lunch
Class 10:35-10:55
Lunch 10:55-11:19
Class 11:23-12:07

3rd Lunch
Class 10:35-11:19
Lunch 11:19-11:43
Class 11:47-12:07

4th Lunch
Class 10:35-11:43
Lunch 11:43-12:07

SAMPLE 5 - VARIABLE TIME BLOCKS, FIVE OR SIX PERIOD DAY

GREENWICH HIGH SCHOOL, GREENWICH, CONNECTICUT

APPENDIX A

DIRECTORY OF PUBLISHERS, FILM AND FILMSTRIP DISTRIBUTORS, AND SCIENTIFIC SUPPLY HOUSES

APPENDIX A

Directory of Publishers

Abelard Schuman, Ltd., 257 Park Avenue South, New York, New York 10010
Abingdon Press, 201 Eighth Avenue South, Nashville, Tennessee 37202
Addison-Wesley Publishing Company, Inc. Reading, Massachusetts 01867
American Book Company, 450 West 33 Street, New York, New York 10001
American Dental Association, 211 East Chicago Avenue, Chicago, Illinois 60611
Atheneum Publishers, 122 East 42 Street, New York, New York 10017
Avon Books, 959 Eighth Avenue, New York, New York 10019
Ballantine Books, Inc., 101 Fifth Avenue, New York, New York 10003
Barnes & Noble, Inc., 105 Fifth Avenue, New York, New York 10003
M. Barrows & Company, 425 Park Avenue South, New York, New York 10016
Basic Books, Inc., Publishers, 404 Park Avenue South, New York, New York 10016
Benefic Press, 10300 West Roosevelt Road, Westchester, Illinois 60153
The Benjamin Company, Inc., 485 Madison Avenue, New York, New York 10022
The Bobbs-Merrill Company Inc., 4300 West 62 Street, Indianapolis, Indiana 46268
Boxwood Press, Box 7171, Pittsburgh, Pennsylvania 15213
Chandler Publishing Company, 124 Spear Street, San Francisco, California 94105
Children's Press, 1224 West Van Buren Street, Chicago, Illinois 60607
William Collins Sons & Company, Ltd., 215 Park Avenue South, New York, New York 10003
Conway Research, Inc., 2600 Apple Valley Road, Atlanta, Georgia 30319
Cornell University Press, 124 Roberts Place, Ithaca, New York 14850
Coward, McCann & Geoghegan, Inc., 200 Madison Avenue, New York, New York 10016
Creative Educational Society, Inc. 515 North Front Street, Mansato, Minnesota 56001
Criterion Books, 257 Park Avenue South, New York, New York 10010
Crowell Collier and Macmillan, Inc., 866 Third Avenue, New York, New York 10022
Thomas Y. Crowell Company 201 Park Avenue South, New York, New York 10003
Crown Publishers, Inc., 419 Park Avenue South, New York, New York 10016
The Delacorte Press, 750 Third Avenue, New York, New York 10017
The Dial Press, 750 Third Avenue, New York, New York 10017
Dodd, Mead & Company, 79 Madison Avenue, New York, New York 10016
M. A. Donohue & Company, 2855 Shermer Road, Northbrook, Illinois 60062
Doubleday & Company, Inc., Garden City, New York 11530
Dover Publications, Inc., 180 Varick Street, New York, New York 10014

E. P. Dutton & Company, Inc., 201 Park Avenue South, New York, New York 10003
Follett Corporation, 1010 West Washington Boulevard, Chicago, Illinois 60607
Franklin Publishing Company, 2047 Locust Street, Philadelphia, Pennsylvania 19104
Freeman, Cooper & Company, 1736 Stockton Street, San Francisco, California 94133
Garrard Publishing Company, 1607 North Market Street, Champaign, Illinois 61820
Golden Press, 850 Third Avenue, New York, New York 10022
Grossett & Dunlap, Inc., 51 Madison Avenue, New York, New York 10010
Hammond Inc., Maplewood, New Jersey 07040
Harcourt Brace Jovanovich, Inc., 757 Third Avenue, New York, New York 10017
Harper & Row, Publishers, 49 East 33 Street, New York, New York 10016
Harvard University Press, 79 Garden Street, Cambridge, Massachusetts 02138
Harvey House, Inc., Publishers, Irvington-on-Hudson, New York 10533
Hastings House, Publishers, Inc., 10 East 40 Street, New York, New York 10016
Hawthorn Books, Inc., 70 Fifth Avenue, New York, New York 10011
D. C. Heath & Company, 125 Spring Street, Lexington, Massachusetts 02173
Holiday House, Inc., 18 East 56 Street, New York, New York 10022
Holt, Rinehart & Winston, Inc., 383 Madison Avenue, New York, New York 10017
Houghton Mifflin Company, 2 Park Street, Boston, Massachusetts 02107
The John Day Company, Inc., 257 Park Avenue South, New York, New York 10010
Alfred A. Knopf, Inc., 201 East 50 Street, New York, New York 10022
Lerner Publications Company, 241 First Avenue North, Minneapolis, Minnesota 55401
J. B. Lippincott Company, East Washington Square, Philadelphia, Pennsylvania 19105
Little, Brown and Company, 34 Beacon Street, Boston, Massachusetts 02106
Lothrop, Lee & Shepard Company, Inc., 105 Madison Avenue, New York, New York 10016
McGraw-Hill, 330 West 42 Street, New York, New York 10036
David McKay, Inc., 750 Third Avenue, New York, New York 10017
The Macmillan Company, 866 Third Avenue, New York, New York 10022
Melmont Publishers, 1224 West Van Buren Street, Chicago, Illinois 60607
Mentor Books. *See* American Book Company
Charles E. Merrill Publishing Company, 1300 Alum Creek Drive, Columbus, Ohio 43216
William Morrow & Company, Inc., 105 Madison Avenue, New York, New York 10016
National Audubon Society, 1130 Fifth Avenue, New York, New York 10018
National Science Teacher's Association, 1201 16 Street, N.W., Washington, D.C.
Natural History Press, 277 Park Avenue, New York, New York 10017

The New American Company, Inc., 1301 Avenue of the Americas, New York, New York 10019
W. W. Norton & Company, Inc., 55 Fifth Avenue, New York, New York 10003
Oceanography Unlimited, Inc., 91 Delaware Avenue, Paterson, New Jersey 07503
Oxford University Press, 200 Madison Avenue, New York, New York 10016
Pantheon Books, Inc., 201 East 50 Street, New York, New York 10022
Parents' Magazine Press, 52 Vanderbilt Avenue, New York, New York 10022
Pelican Publishing Company, Inc., 630 Burmaster Street, Gretna, Louisiana 70053
S. G. Phillips, Inc., 305 West 86 Street, New York, New York 10024
Pocket Books, 630 Fifth Avenue, New York, New York 10020
Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632
G. P. Putnam's Sons, 200 Madison Avenue, New York, New York 10016
Rand McNally & Company, Box 7600, Chicago, Illinois 60680
Random House, Inc., 201 East 50 Street, New York, New York 10022
St. Martin's Press, Inc., 175 Fifth Avenue, New York, New York 10010
Howard W. Sams & Company, Inc., 4300 West 62 Street, Indianapolis, Indiana 46268
Scholastic Book Services, 50 West 44 Street, New York, New York 10036
Scott, Foresman and Company, 1900 East Lake Avenue, Glenview, Illinois 60025
Charles Scribner's Sons, 597 Fifth Avenue, New York, New York 10017
Simon & Schuster, Inc., 630 Fifth Avenue, New York, New York 10020
Steck-Vaughn Company, Box 2028, Austin, Texas 78767
Sterling Publishing Company, Inc., 419 Park Avenue South, New York, New York 10017
Taplinger Publishing Company, Inc., 200 Park Avenue South, New York, New York 10003
Teachers College Press, Columbia University, New York, New York 10027
Teachers Publishing Corporation, 866 Third Avenue, New York, New York 10022
Charles C. Thomas, 301-27 East Lawrence Avenue, Springfield, Illinois 62703
Time-Life Books, Rockefeller Center, New York, New York 10020
Frederick Ungar, Inc., 250 Park Avenue South, New York, New York 10003
University of Arizona Press, Box 3398, Tucson, Arizona 85722
University of California Press, 2223 Fulton Street, Berkeley, California 94720
University of Chicago Press, 5801 Ellis Avenue, Chicago, Illinois 60637
University of Michigan Press, Ann Arbor, Michigan 48106
University of Oklahoma Press, 1005 Asp Avenue, Norman, Oklahoma 73069
Vanguard Press, Inc., 424 Madison Avenue, New York, New York 10017
Van Nostrand Reinhold Company, 450 West 33 Street, New York, New York 10001
The Viking Press, Inc., 625 Madison Avenue, New York, New York 10022
Wadsworth Publishing Company, Inc., Belmont, California 94002
Henry Z. Walck, Inc., 191 Union Square West, New York, New York 10003

Walker & Company, 720 Fifth Avenue, New York, New York 10019
Frederick Warne & Company, Inc., 101 Fifth Avenue, New York, New York 10003
Warner Press, Inc., 1200 East Fifth Street, Anderson, Indiana 46012
Washington Square Press, 680 Fifth Avenue, New York, New York 10020
Albert Whiteman & Company, 560 West Lake Street, Chicago, Illinois 60606
John Wiley & Sons, Inc., 605 Third Avenue, New York, New York 10016
World Publishing Company, 110 East 59 Street, New York, New York 10022
Yale University Press, 149 York Street, New Haven, Connecticut 06511
Young Scott Books, Reading, Massachusetts 01867

Directory of Film and Filmstrip Distributors

Academy Films, 14 N. Seward Street, Los Angeles, California 90026
Almanac Films, Inc., 29 East 10 Street, New York, New York 10003
American Telephone & Telegraph, 195 Broadway, New York, New York 10007
Atlantis Productions, 894 Sheffield Place, Thousand Oaks, California 91401
Bailey Films, Inc., 6509 De Longpre Avenue, Los Angeles, California 90028
Herbert E. Budek, P.O. Box 307, Santa Barbara, California 93102
Charles Cahill & Associates, Inc., 5746 Sunset Boulevard, Los Angeles, California 90028
Carousel Films, Inc., 1501 Broadway, New York, New York 10036
Cenco Educational Films, 2600 South Kostner Avenue, Chicago, Illinois 60623
Children's Press, Jackson Boulevard, Racine Avenue, Chicago, Illinois 60602
Churchill Films, 662 North Robertson Boulevard, Los Angeles, California 90069
Contemporary Films, 267 West 25th Street, New York, New York 10001
Coronet Films, 65 East South Water Street, Coronet Building, Chicago, Illinois 60601
Curriculum Materials Corporation, 1319 Vine Street, Philadelphia, Pennsylvania 19107
Walt Disney Productions, Educational Films Division 350 South Buena Vista Avenue, Burbank, California 91503
Du Art Film Labs, Inc., 245 West 55th Street, New York, New York 10019
Herbert M. Elkins Company, 10031 Commerce Avenue, Tujunga, California 91042
Encyclopedia Britannica Educational Corporation, 1150 Wilmette Avenue, Wilmette, Illinois 60091
Eye Gate House, 146-01 Archer Avenue, Jamaica, New York 11435
Film Associates of California, 11559 Santa Monica Boulevard, Los Angeles, California 90025
Filmstrip House, 432 Park Avenue South, New York, New York 10016
Gateway Productions, Inc., 1859 Powell Street, San Francisco, California 94111

William P. Gottlieb Company, 202 East 44th Street, New York, New York 10017
Indiana University Films, Audio-Visual Center, Bloomington, Indiana 47401
Jam Handy Organization, 2821 East Grand Boulevard, Detroit, Michigan 48211
Journal Films, West Diversey Parkway, Chicago, Illinois 60614
Life Magazine Films, 9 Rockefeller Plaza, New York, New York 10020
McGraw-Hill Text Films, 330 West 42 Street, New York, New York 10036
Moody Institute of Science, 12000 East Washington Boulevard, Whittier, California 90606
Henk Newenhouse, Inc., 1017 Longaker Road, Northbrook, Illinois 60069
Oxford University Press, Inc., 200 Madison Avenue, New York, New York 10016
Popular Science Films, 239 West Fairview Boulevard, Inglewood, California 90302
Scribner and Sons, 597 Fifth Avenue, New York, New York 10017
Shell Oil Company, 50 West 50th Street, New York, New York 10020
Society for Visual Education, 1345 Diversey Parkway, Chicago, Illinois 60614
Stanton Films, 7934 Santa Monica Boulevard, Los Angeles, California 90046
United World Films, Universal Education & Visual Arts, 221 Park Avenue South, New York, New York 10003
Young America Films. See McGraw-Hill Text Films

Directory of Scientific Supply Houses

American Science and Engineering, Inc., 20 Overland Street, Boston, Massachusetts 02215
Elementary science supplies and ESS equipment and supplies.
Cambosco Scientific Company, 342 Western Avenue, Boston, Massachusetts 02135
Biological supplies and general scientific equipment.
Carolina Biological Supply Company, Burlington, North Carolina 27215
Models, charts, living and preserved specimens, biological apparatus.
Central Scientific Company, 2600 South Kostner Avenue, Chicago, Illinois 60623
General. Hobby kits for electronics, medicine, geology, optics, and weather.
Difco Laboratories, Inc., 920 Henry, Detroit, Michigan 48201
Culture media and reagents.
Edmund Scientific Corporation, Barrington, New Jersey 08007
Optical supplies, magnets, etc.
Educational Materials and Equipment Company, 46 Lafayette Avenue, New Rochelle, New York 10801
Microscopes, selected geology, chemistry, and physics equipment. Audiovisual materials.

Fischer Scientific Company, 711-732 Forbes Avenue, Pittsburgh, Pennsylvania 15219
General. Molecular models.

General Biological Supply House, 8200 South Hoyne Avenue, Chicago, Illinois 60620
Biological apparatus, models, charts.

Macalaster Bicknell Company of Connecticut, 181 Henry Street, New Haven, Connecticut 06507
General scientific equipment and chemicals.

Macalaster Scientific Company, Routell and Everett Turnpike, Nashua, New Hampshire 03060
Biological supplies and general scientific equipment, environmental supplies, supplies and equipment for alphabet programs (PSSC, CHEMS, BSCS, IPS, PSNS, ESCP).

Sargent-Welch Scientific Company, 7300 North Linder Avenue, Skokie, Illinois 60076
General. Physics apparatus, microscopes, biological equipment, biology specimens.

Science Kit, Inc., 777 East Park Drive, Tonawanda, New York 14150
Biological supplies and general scientific equipment, supplies and equipment for alphabet programs (BSCS, CHEMS, ESCP, IIS, IMB, IME, IPS, ISCS, PP, PSSC, SAPA).

S.E.E., Inc., 3 Bridge Street, Newton, Massachusetts 02158
General. Simple and inexpensive materials for elementary science. ESS equipment supplies.

Stansi Scientific Company, 1231 North Honore Street, Chicago, Illinois 60622
Scientific kits for elementary school.

Ward's Natural Science Establishment, Inc., P.O. Box 1712, Rochester, New York 14603; P.O. Box 1749, Monterey, California 93940
Teaching aids, charts, equipment, geology specimens, materials for biological, natural, and earth sciences.

APPENDIX B

SAFETY RECOMMENDATIONS AND STATE SAFETY LAWS

APPENDIX B

I

CONNECTICUT STATE DEPARTMENT OF EDUCATION
Bureau of School Buildings
Hartford

STORAGE AND USE OF FLAMMABLE AND COMBUSTIBLE LIQUIDS, CHEMICALS, AND GASES IN EDUCATIONAL OCCUPANCIES

Note: It is not the intent of this publication to cover all regulations and hazards governing the proper storage and use of flammable or combustible liquids, chemicals or gases in educational occupancies in Connecticut, but to summarize only and make such regulations and hazards known to persons involved with such items.

Consultation with the local fire marshal in jurisdiction, or the office of the State Fire Marshal, Public Safety Division of the Connecticut State Police in Hartford, is reccommended regarding proper interpretation of the information herein.

This publication was compiled by the State Department of Education's Bureau of School Buildings as a guide only.

REFERENCE MATERIAL USED IN THIS GUIDE

Connecticut State Police Department:

Sec. 29-41	State Fire Safety Code (November 30, 1971)
Sec. 29-62	Regulations Covering the Storage, Use and Transportation of Flammable Liquids (August 28, 1962)
Sec. 29-72	Regulations Governing the Safe Storage, Use and Transportation of Liquified Petroleum Gas

National Fire Protection Association Publications

Standard-30 Flammable & Combustible Liquid Code - (1969)**
Standard-51 Welding & Cutting, Oxygen-Fuel Gas Systems - (1969)
Standard-70 National Electrical Code - (1968)**
Standard-90A Air Conditioning & Ventilation Systems - (1969)**
Fire Protection for Chemicals (NFPA No. SPP-3)
Standard-10 Installation of Portable Fire Extinguishers (1970)**
Standard-33 Spray Finishing Using Flammable Materials - 1969

Standard-325A-Flash Point Index of Trade Name Liquids - 1968
Standard-325M-Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids - (1969)
Standard-49-Hazardous Chemical Data- (1969)
Standard-491M-Manual of Hazardous Chemical Reactions - (1968)
Standard-54-Installation of Gas Appliances, Gas Piping (1969)**
Standard-91-Blower & Exhaust systems for removal of flammable vapors or dust - (1961)**
**Appendix to State Fire Safey Code

I. Storage Limits in Buildings.

A. Flammable and Combustible Liquids.

1. Storage shall be limited to that required for maintenance, demonstration, treatment, and laboratory work. All flammable or combustible liquids in laboratories and at other points of use shall meet the following storage provisions:

   a. No container shall exceed a capacity of one gallon except that safety containers can be of two gallon capacity.
   b. Not more than 10 gallons of flammable or combustible liquids shall be stored outside of a storage cabinet or room, unless stored in safety cans.
   c. Not more than 25 gallons of flammable or combustible liquids shall be stored in safety cans outside of a storage cabinet or room.
   d. Quantities of flammable and combustible liquids in excess of those set forth in this section 4460 of NFPA Standard 30 shall be stored in a storage cabinet or inside storage room.

B. Chemicals and Compounds: Fire Protection For Chemicals-NFPA

1. It should be noted that some chemicals, compounds and metal powders are of a flammable or combustible nature and when mixed together or with water may produce violent reactions and toxic fumes.

   a. All chemicals and compounds of a hazardous nature shall be stored on non-slip shelves in properly vented and constructed metal or wood cabinets.

   b. Do not store any container upon another container at any time if they are of a hazardous nature.

   c. Do not store any chemical or compound adjacent to another on a shelf if such item would react violently with the other item.

   d. Properly label all storage cabinets as to hazard of contents such as "Danger Keep Fire Away, Danger Do Not Use Water, Radioactive Material: etc.

e. Have emergency instructions conspicuously posted near all storage areas or cabinets on proper procedures in case of fire, explosion, chemical reaction or spillage.

f. Hazardous equipment or storage cabinets for hazardous chemicals, compounds or liquids shall not be located adjacent to exits.

C. Oxygen and acetylene use and cylinder storage.

1. Oxygen cylinders shall be separated from fuel gas cylinders or combustible materials (especially oil or grease), a minimum distance of 20 feet or by a non-combustible barrier at least 5 feet high with a fire resistant rating of 30 min. NFPA Standard 51 - Sec. 233.

2. Fuel gas (acetylene) cylinders shall be stored at least 20 ft. from highly combustible materials. NFPA-Standard 51-Sec.211.

3. Cylinders shall be stored where they will not be exposed to excessive rise in temperature (such as near radiators or heaters), physical damage, or tampering by unauthorized persons. NFPA Standard 51-Sec. 211.

4. Empty cylinders shall have their valves closed while in storage or being moved. NFPA Standard 51-Sec. 212.

5. Where valve protection is provided by caps, such caps shall be in place except when cylinders are in service, NFPA Standard 51-Sec.213.

6. Oxygen cylinders cannot be stored with ethers, hydrogen, calcium, carbon monoxide, ordinary fuels, oils or adjacent to any flammable or combustible item of liquid or solid state. See NFPA Standard 49 and 491M for clarification of chemical reactions.

7. Cylinders with leaky valves or fittings that cannot be shut off at valve, shall be removed from building and all sources of ignition and the owner notified immediately. NFPA-Standard 51-Sec. 244.

8. Acetylene cylinders must be stored and used valve end up per NFPA Standard 51-225 and NFPA Fire Protection for Chemicals.

9. Cylinders in service must have proper key attached to cylinder or valve wheel in place per NFPA-Standard 51-Sec. 246.

10. Welding or cutting work shall not be supported by compressed gas cylinders per NFPA Standard 51-Sec. 242.

11. Oxygen cylinder valves must never be oiled or greased and oily rags or gloves shall not come in contact with them. NFPA-Standard 51-Sec. 248(b)

12. Gas regulator shall only be used on one type of gas and must not be interchanged. NFPA-Standard - 55.

13. When parallel length of oxygen and fuel gas hose are taped together, not more than 4" out of each 8" shall be covered with tape. NFPA-Standard 51-Sec. 51-542.

14. Hose shall be inspected frequently for leaks, burns, worn places, loose connections or other defects and such defective hose or connections replaced per NFPA Standard 51-Sec. 546.

15. No combustibles, shall be located within 35 ft. of any welding or cutting operation unless properly shielded by metal or asbestos guards or curtains per NFPA-Standard 51B-Sec. 422.

16. A proper fire extinguisher for type of welding shall be located in welding area per NFPA-Standard-51B, Sec. 429.

D. LP Gas Storage, Use and Transportation of Liquified Gas of Connecticut State Police.

1. Small LP Gas Containers, such as those used for self-contained hand torches and similar applications are limited to a maximum of two and [illegible]-half pounds water capacity (1 lb. LP (Gas Cap.) and not more than two are recommended stored in a whole school per Sec. 29-72-9 (a) (2).

2. Containers in storage (limit 2) per sec. 29-72-78 (a) shall have the valve closed and protective caps where provided, on at all times.

3. Containers in storage per sec. 29-72-76 (3) must be stored away from highly combustible materials and in locations where they are not subject to excessive rise in temperature, physical damage or tampering by unauthorized persons or adjacent to area of public gathering.

4. An emergency master gas shut-off valve must be located in any room or area where there are multiple gas service outlets. This valve and key should be easily accessible to the instructor, such as on the demonstration table or an adjacent wall. NFPA Standard 54 part 2.11.

E. Compressed gas containers,general Fire Protection for Chemicals.

1. Gases which support combustion must be stored away from gases that will burn. Chlorine, florine, nitrogen dioxide, nitrous oxide, nitrogen tetroxide, oxygen and compressed air must not be stored with ammonia, hydrogen acetylene or hydrogen sulfide.

2. Helium, argon and neon (non-flammable inert gas) may be stored with flammable gases.

3. No gas cylinder of any type, flammable or not, and any item under pressure should be stored where it may be subjected to the heat of a fire.

4. Flammable or toxic gases must be stored at or above grade in structures and not in basements.

II. Storage Cabinets

A. Limits

1. Storage cabinets may be used where it is desired to keep more than 10 gallons of flammable liquids in buildings; no container can exceed 5 gallons, and not over 50 gallons should be stored in any one cabinet. Sec. 29-62-85(a).

2. Not more than 3 storage cabinets for flammable or combustible liquids may be in a single fire area per NFPA-Standard 30-Sec. 4210.

B. Construction

1. Metal storage cabinets.

a. Bottom top and sides of cabinet shall be made of sheet iron at least No.18 gauge in thickness and double walled with 1 1/2" air space. Joints shall be riveted, welded or made tight by some equally effective means. Doors shall be of construction equivalent to walls, provided with a 3-point lock and kept closed when not in use; doors sill shall be raised at least 2 inches above bottom of cabinet. (Sec.29-62-85)

2. Wooden storage cabinets.

a. The bottom, sides and top shall be constructed of a grade of plywood at least 1 inch in thickness, which shall not break down or delaminate under fire conditions. All joints shall be rabbetted and shall be fastened in two directions with flathead wood screws. When more than one door is used, there shall be a rabbetted overlap of not less than 1 inch. Hinges shall be mounted in such a manner as to not lose their holding capacity due to loosening or burning out of the screws when subjected to the fire test. NFPA Standard-30 Sec.4222.

3. Labels and Signs

   a. All cabinets shall be conspicuously labeled in red letters "Flammable-Keep Fire Away." Sec. 29-62-85.

C. Locations

1. Access to exits shall be so arranged that it will not be necessary to travel toward an area of high hazard such as storage cabinets or open storage unless the path of travel is effectively shielded by suitable partitions or other physical barriers Sec. 29-41-510 (e) of State Fire Safety Code.

2. Storage cabinets must be used for the storage of flammable or combustible liquids that are stored in any room or area that is not a properly designed and constructed storage area or room.

III. Storage Rooms:

A. General

1. Rooms that do not meet code requirements for construction ventilation and drainage per NFPA Standard 30-Sec. 4210 are limited to 3 storage cabinets.

Example in some schools: Science and Chemistry Preparation and Storage Rooms, Industrial Art, Arts and Crafts, and Stage Craft Storage Rooms and related Laboratories and shops.

2. Rooms for the storage of flammable or combustible liquids in schools in excess of 150 gallons, should be at or above grade, preferable in a corner of building and be located aways from combustible or valuable contents. Sec. 29-62-67 (d).

3. Open flame and smoking shall not be permitted in flammable or combustible liquid storage areas per NFPA Standard 30 Sec.4630 and Sec.29-62-74.

4. Materials which will react with water shall not be stored in the same room with flammable or combustible liquids per NFPA Standard 30 - Sec. 4640.

5. Flammable liquids, such as gasoline, lacquers , varnish, turpentine, paints, and oils when stored in sealed containers present a potential rather than an active hazard. The active hazard results when the containers are open and when the liquids are transferred or handled by means of open containers or receptacles. This hazard is due to the opportunity afforded the vapors to escape and become ignited by various means. The degree of hazard in such cases depends upon the capacity of the containers, the volatility of the liquid, and to a certain extent

upon the area of the liquid surface exposed. Sec. 29-62-67 (a).

6. When stored in sealed containers (i.e., "dead storage") the hazard is that due to the possibility of storage becoming involved by fire from without.

   Under such conditions the degree of hazard will depend upon the character of the liquid as well as the capacity of the container. For this reason the storage of large amounts of flammable liquids in containers of large size, or handling or mixing operations involving or exposing considerable amounts of such liquids should be segregated and restricted to specially constructed storage rooms or storage houses as hereinafter described. Sec. 29-62-67(b).

B. Existing Construction per Sec.29-62-76 (a) through (b)

1. Walls, floors and ceiling shall be of construction having a fire-resistive rating of not less than one hour with all interior room surfaces of approved non-combustible material.

2. Exterior doors or door openings to other rooms shall be provided with non-combustible liquid tight sills or ramps raised at least 6 inches.

3. Floors should be waterproof and arranged to drain to a safe location.

4. All door openings to other rooms shall be protected by an approved fire door of automatic or self-closing type, suitable for openings in partitions.

5. Where other portions of the building or other properties are exposed, windows shall be protected in a standard manner.

6. Shelving shall be non-combustible.

C. New Construction per Sec. 29-62-68 (a) through (f).

Note: New construction in accordance with Fire Safety Code effective Nov. 30, 1971 must conform with these requirements.

1. Walls, floors and ceiling shall be of non-combustible construction having a fire-resistance rating of not less than two hours.

2. Exterior doors or door openings to other rooms shall be provided with non-combustible liquid-tight sills or ramps raised at least 6 inches.

3. Floors should be waterproof and arranged to drain to a safe location.

4. All door openings to other rooms shall be protected by an approved fire door of automatic or self-closing type,suitable for openings in partitions.

5. Where other portions of the building or other properties are exposed, windows shall be protected in a standard manner.

6. Shelving shall be non-combustible.

D. Electrical Installations

a. Electrical installations per Sec.29-62-69(a) shall conform with NFPA Standard 70 Article 501-Class I installations, Division 1 or 2 as applicable.

b. Electrical receptacles and plugs shall be of the grounded type per NFPA Standard 70-Article 501-12.

c. Electrical receptacles,plugs,lights,motors,etc. shall conform with NFPA Standard 70-Article 501-Class 1, Division 1,installations for areas where flammable liquids are stored within a room.

E. Ventilation:

a. Every inside storage room for the storage of flammable or combustible liquids shall be approved with either a gravity or mechanical exhaust ventilation system, which will provide for a complete change of air within room at least six times per hour with control switch; if mechanical,located outside of the door. Ventilation and lights shall be operated by the same switch. Ref.NFPA Standard 30-sec.4313.

b. Ventilation for areas where flammable or combustible liquids,chemicals or gas are used or stored cannot be recirculated per NFPA Standard 90A-Sec. 401.

F. Storage Limits

1. One hour non-combustible construction per Sec.29-62-83(a) that is not protected by an approved automatic extinguishing system shall contain not more than:

   a. 60 gallons of a flammable liquid with a flash point below 25°F such as: Class 1 liquids.

   b. 215 gallons of a flammable liquid with a flash point of 25°F and below 70°F such as: Class 11 liquids.

   c. 275 gallons of a flammable liquid with a flash point of 70°F and below 200°F such as: Class 111 liquids.

2. Two hour fire resistant construction per Sec. 29-62-75(a) that is not protected by an approved automatic extinguishing system shall contain not more than:

   a. 275 gallons of a flammable liquid with a flash point below 25°F such as: Class 1 liquids.

   b. 275 gallons of a flammable liquid with a flash point of 25°F and below 70°F such as: Class 11 liquids.

   c. 550 gallons of flammable liquid with a flash point of 70°F and below 200°F such as: Class 111 liquids.

IV. Finishing Rooms and Paint Spray Booths

A. Construction:

1. Finishing rooms per sec. 29-41-9.20 require 2 hour fire resistive walls, ceilings and solid floor in new construction and sec. 29-41-6.29(e) requires walls, ceilings and floors of solid construction with self-closing doors and proper fire detection or sprinkler protection in existing construction.

2. Spray booths per NFPA-Standard-33 Chapter 3 shall be substantially constructed of steel not thinner than No. 18 U.S. gauge, securely and rigidly supported, except that aluminum or other substantial non-combustible material may be used for intermittent or low volume spraying.

   a. Interior surfaces must be smooth and readily cleanable.

   b. Floor must be non-combustible and readily cleanable both within and around booth.

   c. Baffle plates if installed must be non-combustible and easily removed for cleaning.

   d. Booths having a frontal opening area larger than 9 s.f. must have a metal deflector of curtain not less than 2 1/2" deep at upper edge over opening.

   e. Lights must be properly protected from paint residue and protector not subject to high temperature.

B. Locations

1. Finishing rooms shall per NFPA Standard 91 sec. 302 and per sec. 29-41-5.10(e) be located preferably on

exterior walls.

2. Finishing rooms or booths per NFPA Standard 33 Sec.204, preferably should not be located in basements.

3. No open flame or spark producing equipment is permitted per NFPA Standard 33 spec.402 in any spraying area, nor within 20 feet thereof, unless properly separated by a non-combustible partition.

4. A clear space of not less than three feet on all sides shall be kept free from storage or combustible construction and all portions must be readily accessible for cleaning per NFPA Standard 33 Sec. 309.

C. Electrical Installations: Chapter 4, NFPA Standard 33.

1. Electrical wiring and equipment shall conform to NFPA Standard 33-Chapter 4 and NFPA-Standard-70.

    a. Electrical wiring and equipment located within spraying area must be explosion proof type approved for NFPA-Standard 70, class 1, division 1, Hazardous Locations per sec. 406.

    b. Electrical wiring and equipment within 20 ft. of spraying area and not separated by a non-combustible partition, shall not produce sparks and conform to NFPA-Standard 70 for Class 1, Division 2 Hazardous Locations per 407.

    c. Portable electric lamps shall not be used in any spraying area during spraying operations, if used during cleaning they must conform to hazardous class 1 locations. Electrical lamps within 20 feet of spraying area must be totally enclosed and have metal guards per sec. 408 and 409.

    d. All metal parts of spray booths; exhaust ducts and piping systems conveying flammable or combustible liquids shall be properly electrically grounded per sec. 410.

D. Ventilation:

1. Ventilation must conform to NFPA Standard 33 Chapter 5 and standard-91.

    a. No mixing of dissimilar matters in ventilation ducts is permitted per standard 91 - sec. 325.

b. Each spray booth must have an independent exhaust to exterior, except 3 units may be interconnected if frontal opening total does not exceed 18 s.f. and all are for use of same spray material per standard 33-sec.504.

c. Electric motors for exhaust fans cannot be within booths or ducts per NFPA Standard 33 sec. 506.

d. Spray booths shall be designed to create a negative pressure and sweep air currents towards exhaust outlet per NFPA Standard 33 - sec. 301.

e. The terminal discharge from exhaust duct must be 6 ft. from a combustible exterior wall or roof and not discharge towards combustible construction or opening in any non-combustible exterior wall within 25 ft. per NFPA Standard 33 - sec. 510.

f. Vapor removal duct must go directly to exterior and not pass through stories above Standard 33 - sec.512.

E. Storage of flammable liquids in finishing rooms

1. Not more than 50 gallons of flammable or combustible liquids can be stored in a finishing room and such storage must be in a proper metal or wood storage cabinet per NFPA Standard 33 - sec. 603.

2. Container supplying spray nozzles by gravity feed per NFPA Standard 33 - sec. 608 cannot exceed 10 gallons capacity.

F. Maintenance: NFPA Standard 33 - Chapter 8

1. All spraying areas shall be kept as free as possible from accumulations of residues as practical per sec. 803.

2. Cleaning tools must be non-sparking, per sec.804.

3. A "No Smoking" sign shall be conspicuously posted in all spraying rooms or areas and in paint storage rooms.

4. A sign reading NO WELDING - The use of welding or cutting equipment in, on or around this spray booth and duct (or paint storage area) is dangerous because of fire and explosion, per sec. 812 must be conspicuously posted at all spraying areas and paint storage areas.

5. A proper fire extinguisher of at least 12-B units per NFPA Standard -10 is required within room or not more than 10' from room.

V. Waste and Containers

A. Approved waste can or cans of metal with self-closing lids shall be provided for the storage of oily rags or waste and contents shall be removed daily per Sec.29-62-72 from all areas where used.

VI. Fire Extinguishers

a. At least one portable fire extinguisher having a rating of not less than 12-B units shall be located outside of, but not more than 10 ft. from the door openings into any room used for storage of flammable or combustible liquids NFPA Standard 30 - Sec. 4611.

b. At least one portable fire extinguisher having a rating of not less than 12-B units shall be located not less than 10 ft. nor more than 25 ft. from any flammable liquid storage area located outside of a storage room but inside a building. NFPA Standard 30 - Sec. 4612, such as near storage cabinets or open storage.

c. Fire extinguishers should be inspected once a month to see if they are in proper place, have been tampered with or damaged, or have been used? NFPA Standard 10- Sec. 5100 and 2210.

d. Fire extinguishers must be maintained once a year and when removed they must be replaced immediately by a similar spare. NFPA Standard 10 - Sec. 5200.

e. Fire extinguishers must have tags showing recharge date, and initial of responsible person doing so. NFPA Standard 10 - Sec. 5230.

f. A class D type extinguisher should be available where sodium, potasium, magnesium or other Hazardous chemicals are used or stored.

g. No fire extinguisher containing Carbon Tetrachloride or Chlorobromomethane is permitted per General Statute Sec. 29-44a in a school.

VII. Fire Explosion and Spillage Emergency (Common Sense)

A. Persons using any flammable liquid, chemical or gas should have knowledge of how to handle any possible emergency that could take place during its use.

B. Depending upon individual emergency situations persons using any flammable liquid, chemical or gas should:

1. Know Fire Safety procedures of school or area.

2. Be capable of deciding immediately whether to:

   a. sound fire alarm
   b. evaluate room or area or
   c. use emergency fire extinguisher or first aid

3. Have knowledge of first aid for chemical burns, thermal burns or injuries and what to do in such emergency.

4. Know the possible reaction of such items when exposed to:

   a. fire or heat
   b. water
   c. other chemicals
   d. human body
   e. air

VII. Definition and Helps

A. Safety can is approved container, of not more than 5 gallons capacity, having a spring-closing lid and spout cover and so designed that it will safely relieve internal pressure when subjected to fire exposure. NFPA Standard 30 Definition.

B. Flammable Liquids

Regulations covering the storage, use and transportation of flammable liquids defines flammable liquid as a liquid with a flash point below 200°F. Sec.29-62-1(c) divides flammable liquids into the following three classes according to flash point.

1. Class I liquids with a flash point below 25°F.
2. Class II liquids with a flash point above that of class I and below 70°F.
3. Class III liquids with a flash point above that of class II and below 200°F.
4. Flash Point of a liquid shall mean the temperature at which it gives off vapor sufficient to form an eligible mixture with the air near the surface of the liquid or within the vessel as determined by appropriate test procedures.

C. Flash Points of items.

1. National Fire Protection Association Standard 325A "Flash Point Index of Trade Name Liquids" is an excellent guide for flash points of liquid.

2. The National Fire Protection Assoc. Guide on Hazardous Materials should be referred to for Flash Points of liquids

and chemicals; and for materials that will react with water. It is also a fire fighting guide.

3. The following items, broken down as to Class I, II or III flammable liquids are examples as to flash points of some items commonly found in schools and not thought of as flammable.

   a. Class I flammable liquids, gases and chemicals.

Aqua Solve No. 767	
Emulsion degreases	
Lacquer Thinner	0°F
Gasoline	20°F-30°F
Grow Solvent LT-1207	45°F
Lacquer Thinner	0°F

Weldwood Contract Cement	20°F
" " "Fast Dry	0°F
Acetone	0°F
Citgo Rubber Solvent	0°F

   b. Class II flammable liquids,gases & chemicals.

Aero Gloss Dope	36°F
Aero Gloss Deope Thinner	38°F
Amercoat No.23 or 21	34°F
BDC Spirit Fluid	53°F
A.B.Dick Economy Spirit Fluid	52°F
Dow-Corning paint vehicle 806-840	50°F
Fabulon	55°F
Trico Windshield Solvent	42°F

Cascade-duplicating fluid	64°F
Color copy-spirit duplicating fluid	54°F
Copybrite duplicating fluid	53.6-57.2°
Ditto Direct Process Fluid	53.9°
Dow-Corning resin;2103, 2104,2105 and 2106	
Lucite lacquers,aersol-coating	40°F
Zerone Anti-Rust Anti-Freeze	61°F

   c. Class III Flammable liquids:

Duco cement	below80°F
Standard #325 Thinner	102°F
Johnsons car plate wax	92°F
Johnsons liquid wax	77°F
Johnsons Traffic wax	85°F
Devo Paint & Varnish Remover,cream or liquid	78°F
T&R Brand Gum Turpentine	95°F
Rust-Oleum paint	80°F
Kerosene	100°F
Aladdin Thinner	106.7°F
All Sheen Mop Dressing	138.2°F
Black Flag Insect Spray	159°F
Bruce Cleaning Wax	113°F
Bruce Floor Cleaner	115°F
Bruning 3000 replenisher #32-380	116°F
Cosmoline Rust Preventive	102° to 120°F

WD-40 lubricant	96°F
Star Gym Finish Wood floor finish	105°F
Johnsons Paste Wax	84°F
Traffic wax	86°F
Delco Hydraulic Brake fluid	95°F
Deft Wood Finishes	80°F
Spar Varnish	110°F
Addressograph Rubber,Roller and Metal type Cleaner	107.6°F
Atlan Flame-Crete fire Retardent semi-gloss varnish	96.8°F
Blackboard treatment	155°F
Bruce gym finish	112°F
Bruning 3000 developer	
Bruning 3000 developer #32-375	122°F

Fabuloy	128°F
FoMo Co. undercoating 8A-19515-B	102°F
Renuzit spot remover	119°F
Weldwood Color Tones Interior Wood Stains	100°F
Conq-R-Dust mop treatment	166°F
DuraBond floor seal	95°to 100°F
Fire Retardent paint E.I.DuPont de Memours Mfg. Co.	80°to 150°F
Pine Oil Disinfectant	147°to175°F
Gunk Engine Brite	152°F

D. The following are chemical, gases, or metals found in schools and their possible hazards.

1. Some chemicals that will react with water or moisture, found in schools are:

Ammonium Nitrate
Sodium, Sodium Perioxide, Sodium-Potassium Alloys
Potassium, Potassium Perioxide
Aluminum dust or powder, Aluminum Chloride
Calcium, Calcium Carbide
Fluorine
Lithium, Lithium Aluminum Hydride, Lithium Hydride
Magnesium powder or dust, including alloys
Zinc powder or dust
Phosphorus Pentasulfide, Phosphorus Trichloride

2. Reactive means: a substance of solid or liquid state that may react when mixed or comes in contact with another substance, creating fire, explosion or toxic fumes as the case may be.

3. Some possibly incompatible chemicals found in schools are:

Acetic and Glacial Acid	109°F
Propane (gas)	
Gasoline	45°F
Potassium Permanganate (reactive)	
Sulfuric acid (reactive)	
Hydrogen Peroxide (reactive)	
Bromine (reactive)	
Chlorine (reactive)	
Acetylene (gas)	
Pentane (gas)	
Methyl alcohol	52°F
Isopropyl alcohol	53°F
Ethyl alcohol	55°F
Ethyl Ether	49°F
Kerosene	100°F
Hydrogen sulfide gas	
Benzene	120°F
Potassium chlorate (reactive)	
Halogens (reactive)	
Caron Tetrachloride (toxic)	
Nitric Acid (reactive)	
Phosphorus Red (reactive)	
Phosphorus White or Yellow (reactive)	
Hydrogen (gas)	
Butane (gas)	76°F
Glycerine	320°F
Diethylene Glycol	225°F
Sulfur(reactive)	
Oxygen (gas)	

APPENDIX B
II

FIRE SAFETY AND PREVENTION GUIDE
FOR

LABORATORIES - (Science, Chemistry, etc.)

INDUSTRIAL ART LABORATORIES

STAGE CRAFT

VOCATIONAL AGRICULTURE

ARTS & CRAFTS

AND RELATED AREAS

Providing for personal safety from fire hazards when a building is occupied is of uppermost importance. The best structures can be rebuilt, but a person's life cannot.

CONNECTICUT STATE DEPARTMENT OF EDUCATION

BUREAU OF SCHOOL BUILDINGS

HARTFORD

CONNECTICUT STATE DEPARTMENT OF EDUCATION
Bureau of School Buildings
Hartford

The following is a recommended guide only, and it is not the intent of this publication to cover all requirements of the State Fire Safety Code regarding proper housekeeping and maintenance in educational Laboratories, Industrial Art, State Craft, Vocational Agriculture, Arts & Crafts and Related Areas, but to summarize only, and make such requirements known to persons involved with such occupancies.

> NOTE: It is intended that this guide be used with pamphlet entitled "Storage and Use of Flammable and Combustible Liquids, Chemicals, and Gases In Educational Occupancies" published by this department, for technical regulations regarding such items.

Questions regarding this guide should be directed to the State Fire Marshal's Office, of the Public Safety Division of the State Policy, or the Department of Education, Bureau of School Buildings.

Consultation with the Department of Education's related consultant regarding safe procedures and equipment locations and with the local fire marshal in jurisdiction for local requirements is recommended.

> NOTE: Section 29-41-2.01(b) of the Connecticut Fire Safety Code states: "Every building or structure shall be so constructed, arranged, equipped, maintained and operated as to avoid undue danger to the lives and safety of its occupants from fire, smoke fumes or resulting,panic during the period of time, reasonably necessary for the excape from the building or structure in case of fire or other emergency."

I. RECOMMENDED GUIDE

A. OCCUPANCIES

Chemistry laboratories and Arts and Crafts rooms built prior to November 30, 1971 and any classrooms or laboratory built after November 30, 1971 exceeding 1000 square feet in area, or 50 occupants, shall have two separate and distinct means of egress as remote as possible from one another.

Industrial Art shops, Stage Craft and Vocational Agriculture shops built prior to November 30, 1971 shall have two separate and distinct means of egress, as remote as possible from one another. One to an interior corridor and one directly outside of building or through adjoining room and outside of building, in areas built after November 30, 1971 exceeding 1000 square feet in area of 50 occupants, shall have two separate and distinct means of egress as remote as possible from one another.

Laboratories, Industrial Art Shops, Arts & Crafts, Stage Craft, Vocational Agriculture and all related areas in Open and Flexible Plan facilities must be separated from school areas by one hour fire resistive construction and have exits independent from other areas.

B. GENERAL OCCUPANCY REQUIREMENTS

1. All furniture and equipment located in any space must be located so that there are adequate exit aisles, and doors are not blocked to prevent usage.

2. Do not allow occupants' coats to be stacked on furniture or equipment near doors from a space where they may impede exiting.

3. Have all occupants, day or night, informed of evacuation plan and have emergency exiting instructions posted in all spaces, indicating main and alternate exit routes.

4. All openings around ~~pipes, conduits, ducts and~~ just holes through any interior wall, through any floor and openings exposing the structure, must be sealed with a non-combustible material.

5. Keep heating and ventilation units clear of stacked papers, books, drying cloths, and clean of dirt and dust.

6. Make sure all gas and electrical appliances and equipment are shut off at end of day or evening classes.

7. Use only a reasonable amount of combustible decorations in instructional areas, and in no case can an entire wall be covered with combustible materials nor shall they be used adjacent to an exit.

8. Maintain all doors so they swing free and don't stick or bind.

9. Do not lock, block, chain, or padlock any exit door to prevent its use as a means of egress.

10. Maintain all door hardware in a proper operating condition and replace cracked or broken glass view panels.

II. FIRE DETECTION UNITS

1. Fire detectors are required for complete coverage of any room where experiments or work are conducted with an open flame, chemicals, flammable liquids and all work areas, finishing room areas, garages, all preparation rooms, storage rooms and demonstration rooms that are not sprinkled.

2. Fire detection units must be inspected and cleaned for proper operation, as required by maintenance manuals.

III. FIRE EXTINGUISHERS

1. Have and maintain proper fire extinguishers in all laboratories, all work areas, garages, demonstration rooms, preparation rooms and adjacent to all storage rooms, finishing rooms, welding areas and flammable liquid or chemical storage cabinets, wherever required by local fire marshals.

2. Personnel must know how to operate and use fire extinguishers.

3. Fire extinguishers must be maintained fully charged, in operable condition and in designated places.

4. Fire extinguishers must be conspiciously located, with instruction label facing out, and be readily assessible at all times.

5. Fire extinguishers must be inspected once a month to make sure they have not been tampered with or used; nozzles are clear and unit is not corroding.

6. Fire extinguishers must be hung so tops of units weighing 40 lbs. or less are not more than 5'0" from floor.

7. Extinguishers removed for recharging or repairs, must be replaced immediately with a spare unit of proper type.

IV. VENTILATION

1. Filters for exhaust hoods, paint spray hoods and mechanical equipment, must be inspected regularly and cleaned when a buildup of residue is noticed.

2. Exhaust from chemical fume hoods, and flammable liquid or chemical storage rooms cannot be intermixed and must go directly to exterior as possible.

V. RUBBISH HANDLING, STORAGE AND RECEPTACLES

1. Rubbish shall be collected as frequently as circumstances require for reasonable fire safety and disposed of at least daily.

2. Sweepings and other refuse must be taken out of the building or to proper trash rooms by cleaners daily.

3. A sufficient number of wastebaskets and other small receptacles for waste and rubbish must be provided where needed and emptied regularly.

4. Approved metal waste containers with covers must be provided for oily rags, chemicals, combustible scrap, and other materials requiring special handling.

VI. STORAGE/STORAGE ROOMS AND AREAS

1. Store all flammable liquids and chemicals in excess of one day's supply, in proper,locked fire-rated cabinets labeled "Flammables-Keep Fire Away." Containers must not exceed 5 gallon capacity, not more than 50 gallons per cabinet and not more than three cabinets per room or fire area.

2. Quantity of flammable liquids in any room is limited to that amount immediately needed for maintenance, demonstration, treatment and laboratory work only, and then no container can exceed (1) one gallon capacity, except that safety containers can be of (2) gallon capacity.

3. Flammable liquids shall be stored in and dispensed from approved containers only and shall be returned to storage area as soon as possible after use.

4. Materials that will react with water shall not be stored in the same cabinet with flammable or combustible liquids.

5. No flammable gas container, butane hand torches, welding

tanks and oxygen tanks can be stored, in an area subject to excessive heat or possible fire, or adjacent to any flammable or combustible liquid.

6. Aerosol cans, and any item stored under pressure, flammable or not, must not be stored where subject to excessive heat or fire.

7. All storage rooms must have walls of solid construction, floor to structure above, any louvers in interior doors facing on egress ways must be blocked off with fire rated materials, and doors require self closing devices.

8. In storage, all items must be stored in a neat, orderly manner.

Industrial art shops and vocational agriculture shops cannot be used for the storage of internal combustion operated equipment, cars, trucks, tractors, lawnmowers, etc. They are for instruction and repair only.

VII. ELECTRICAL

1. Use only U. L. approved fuses, extension cords and appliances and replace when frayed or faulty.

2. Do not use extension cords as a substitute for permanent wiring or attach to building surfaces.

3. Do not run extension cords through holes in the walls, ceilings, floors, ceilings or floors.

4. Extension cords cannot be spliced or be tapped into and do not use multiple plug "octupus" cord arrangements. All electrical power for equipment used by students in shops shall be controlled by emergency master shut-off switches located in a least three remote locations, capable of shutting off all power to equipment within sight in the shop. The main electrical power panel controlling all power in a shop, should be locked at all times, so unauthorized persons can not operate power equipment without the instructors' knowledge.

5. Light switch covers, plug outlet covers, junction box covers and panel covers must be in place at all times.

6. All outlets, switches, and fixtures must be securely and rigidly affixed to structure.

7. Lighting fixtures, outlets, and appliances cannot have

live parts normally exposed.

8. If fuses blow frequently, have electrician check circuit and appliances; do not use higher rated fuse than circuit is designed for.

9. All electrical motors must be kept free of accumulation of dust, dirt and debris.

10. Do not use combustible light shades or affix combustibles to lights.

11. Electrical plug outlets must be grounded and so located as not to be involved with liquid overflows or splashes.

12. Explosion proof fixtures, etc., in hazardous areas must be properly maintained.

VIII. GENERAL

1. An emergency master gas shut-off valve shall be located in any room or area where there are multiple gas service outlets. This valve and key shall be readily accessible to the instructor, such as on the demonstration table or on an adjacent wall.

2. Gas outlets should not be so located on laboratory tables that they could be accidently turned on.

3. Use only alcohol lamps that have non-tip bases, tight-fitting tops, and have them filled and ready for student use. The filling of alcohol lamps during class periods, is dangerous and should not be permitted.

4. Finishing rooms or areas shall be segregated from other areas by non-combustible construction, with wire glass in all interior windows, have explosion proof electrical fixtures and equipment, outward winging self-closing doors without hold open devices, be located on exterior walls if possible, be well vented directly to the outside and be used for no other purpose.

5. Finishing areas or spray booths enclosed or partially enclosed are small concentrated hazardous units and shall be well vented as directly outside as possible, have explosion proof electrical fixtures and equipment, be properly cleaned and maintained and shall not be located adjacent to required exits.

6. Welding or forging areas shall not be directly adjacent to combustible material, spark arresters shall be located around welding cubicals or areas. Such areas shall be properly maintained to prevent the ignition of any adjacent combustible material and have a proper fire extinguisher at hand.

7. Dust collecting units shall be properly maintained, be equipped with devices to prevent a flash back at points of intake if waste material is ignited shall be located on exterior walls and vented directly outside.

IX. SHOP PROJECTS, LABORATORY EXPERIMENTS, OR RELATED PROJECTS

1. Students should be made aware of any possible hazard prior to the start of any project involving the use of hazardous machinery or equipment, the use of dangerous chemicals, compounds or liquids, and what they should do if an emergency arises.

2. Students should know the proper use of all equipment, machines, dangerous chemicals, compounds or liquids prior to using such items and how to properly dispose of waste.

3. Students should not be permitted to indulge in "horseplay" during any shop work experiment or project.

4. Instructors should know how to handle any possible emergency that may transpire in his area of instruction, and have the necessary items readily available to handle such an emergency involving student participation.

5. Students and instructors must wear proper eye protection during experiments involving the danger of splashing chemicals, explosion, flying dust or fragments.

6. Emergency showers and eyewash facilities should be located wherever the eyes or body of any person may be exposed to injurious corosive materials, as in chemistry laboratories.

X. STORAGE OF CHEMICALS AND COMPOUNDS

1. All chemicals, compounds and liquids of a hazardous nature shall be stored on non-slip shelves in properly vented and constructed metal or wood cabinets.

2. Do not store together on a shelf any chemical, compound or liquid that would react violently with one another.

3. Properly label all storage cabinets as to hazard of contents.

4. Have emergency instructions conspicuously posted near all storage areas on proper procedures in case of fire, explosion, chemical reaction or spillage.

5. Hazardous equipment and storage cabinets or rooms for dangerous chemicals, gases, compounds or liquids shall not be located adjacent to exits.

XI. FIRE, EXPLOSION AND SPILLAGE EMERGENCY (COMMON SENSE)

1. Instructor should have knowledge of how to handle any possible emergency that could transpire in a laboratory.

2. Depending upon individual emergency situations the instructor should know:

   a. Fire safety procedures of school;
   b. Be capable of deciding immediately whether to sound fire alarm, evacuate room or use emergency fire first aid;
   c. Have knowledge of first aid for chemical burns or inquiries and how to react in such emergencies;
   d. The possible reactions of dangerous chemicals and compounds during an emergency.

APPENDIX B
III

OBVIOUS FIRE HAZARDS IN CONNECTICUT SCHOOLS

THAT CAN BE CORRECTED BY

GOOD HOUSEKEEPING & MAINTENANCE PRACTICES

PROVIDING FOR PERSONAL SAFETY FROM FIRE HAZARDS WHEN A BUILDING IS OCCUPIED IS OF UPPERMOST IMPORTANCE.................... THE BEST IN STRUCTURES CAN BE REBUILT, BUT A PERSON'S LIFE CANNOT..............

THE NEXT TIME YOU SEE AN
APPARENT FIRE SAFETY HAZARD,
STOP AND THINK -
"WILL I BE A CONTRIBUTING FACTOR
IN NEXT YEAR'S STATISTICS?"

CONNECTICUT STATE DEPARTMENT OF EDUCATION
Bureau of School Buildings
Hartford

The hazards to life from a developing fire are most likely to be:

1. SMOKE AND GASES
2. HEAT
3. FLAME

These hazards can be controlled, and the time available for a safe, rapid evacuation in case of a fire can be extended! When proper measures to control the above hazards are not taken, the time available for a safe, rapid evacuation may not be quite enough, or, zero!

IN THE EVENT OF A FIRE IN YOUR BUILDING

1. How soon will the fire be detected?
2. How rapidly will the fire alarm be sounded?
3. How long will the evacuation take?
4. Will there be enough time in your building for all the above three items to be completed safely?

WHAT CAN YOU DO?

1. Have early detection of fire, and audible fire alarm heard throughout the building, and a safe exit way for rapid evacuation of occupants.
2. ELIMINATE and KEEP REMOVED obvious hazards, thus reducing the possibility of fire and the resulting rapid spread of smoke and gases throughout a building, causing panic and blockage of exits.

FIRE ALARMS AND DETECTION UNITS

1. All fire alarm systems must be tested regularly and properly maintained as required by fire safety code.
2. All fire horns must be heard throughout a building above environmental noises.
3. Fire alarm pull boxes must be readily accessible and not hidden from view.
4. Fire and smoke detection units must be inspected and cleaned as required for proper operation.
5. Sprinkler control valves must be accessible, in open position and related heads free of obstruction by at least 18 inches.

FIRE EXTINGUISHERS

1. Have and maintain proper fire extinguishers in all corridors, boiler or heater rooms, kitchens, stages, cafeterias, gymnasiums, auditoriums, maintenance shops and areas, welding and painting areas, garages, laboratories, arts and crafts areas, mechanical equipment rooms and where required by fire safety code.

2. Personnel must know how to operate and use fire extinguishers.

3. Fire extinguishers must be maintained fully charged, in operable condition and in disignated place.

4. Fire extinguishers must be conspiciously located, with instruction label facing out, and be readily accessible at all times.

5. Fire extinguishers must be inspected once a month to make sure it has not been tampered with, used, physically damaged; nozzles are clear and unit is not corroding.

6. Fire extinguishers must be hung so tops of units weighing 40 lbs. or less are not more than 5'-0" from floor.

7. Extinguishers removed for recharging, or repairs must be replaced immediately with a spare unit of proper type.

MEANS OF EGRESS

1. Remove all rubbish, general storage, soda and candy dispensers, coat racks, rugs and floor mats with curled up edges, snow blowers and lawnmowers, trash containers and anything else that would impede exiting through a corridor.

2. No occupancy or storage of any kind is permitted within or under any exit stairway or ramp.

3. All egress stairways must be segregated from all corridors and spaces at all floor levels and exit directly to the exterior.

4. Decorations in corridors and classrooms must be flame retardant and must be limited.

5. All exits must be maintained usable during any construction at a building, when it is occupied.

6. All exterior fire excapes, unenclosed exit stairwalls, and sidewalks leading from any exit must be maintained free of ice, snow, rubbish containers, parked cars and trucks and any other impediment.

7. All furniture and equipment located in any space must be located so there are adequate exit aisles and doors are not blocked to prevent usage.

8. Do not allow occupants' coats to be stacked upon furniture or equipment near doors from a space, where they may impede exiting.

9. Have all occupants, day or night, informed of evacuation plan and have emergency exiting instructions posted in all spaces, indicating main and alternate exit routes.

10. All openings around pipes, conduits, ducts and just holes through any interior wall, through any floor and openings exposing the structure must be sealed with a non-combustible material.

11. Stair treads and hand rails must be maintained free of defects.

12. When 200 or more movable seats are used in a cafeteria, gymnasium or combination use room for lecture or meeting purposes, they must be tied or clamped together in groups of not less than three nor more than seven with proper aisles between every fourteen seats. This requirement does not apply to seats at dining tables, and the capacity of room must not exceed limits posted by Fire Marshal.

DOORS

1. Label all interior doors, entering exit stairtowers "Fire Exit: Keep Door Closed."

2. Remove any device that will hold open a fire door, corridor smoke or fire door, interior boiler room, or mechanical equipment room door, interior kitchen or storage room door, interior door from a gymnasium, auditorium or cafeteria and any interior door opening into a stairtower and maintain closers in an operable condition, so such doors will be self-closing and remain closed. (Fusable link hold open devices are not permitted)

3. Maintain all doors so they swing free and don't stick or bind.

4. Do not lock, block or chain and padlock any exit door to prevent its use as a means of egress.

5. Maintain all door hardware in a proper operating condition and replace cracked or broken glass view panels.

BOILER, HEATER ROOMS AND MECHANICAL EQUIPMENT ROOMS

1. All walls must extend from floor to deck above, be of solid construction, have all openings around pipes, conduits, ducts and just holes through walls and floors sealed with a fire resistive material.

2. No storage of any kind is permitted and such areas cannot be used as custodial offices or maintenance shops.

3. All vents to the exterior must be kept open at all times.

4. Properly maintain all equipment in accordance with equipment operating manuals.

5. Chimney flue connections must be tight and free of defects.

VENTILATION

1. No storage is permitted in any air plenum and such plenums, ductwork and grills must be free of dirt and dust collections.

2. Filters for kitchen hoods, paint spray hoods, mechanical equipment, and clothes-dryers must be inspected regularly and cleaned when a buildup of residue is noticed.

3. Kitchen hoods, dust collectors, finishing rooms, paint spray booths, chemical fume hoods, and exhaust from flammable liquid storage rooms cannot be intermixed and must go as directly to exterior as possible.

4. Seal all openings into unused vertical air shafts with a non-combustible material.

RUBBISH HANDLING, STORAGE AND RECEPTACLES

1. Rubbish shall be collected as frequently as circumstances require for reasonable fire safety and disposed of at least daily.

2. Sweepings and other refuse must be taken out of the building or to proper trash room by cleaners.

3. A routine must be established for the regular removal of rubbish and other unnecessary combustible materials from yards and outside storage.

4. Places must be designated where rubbish may be placed temporarily, prior to being removed and such location must not endanger building.

5. Large quantities of rubbish must be handled in metal ashcans, drums or similar non-combustible containers.

6. A sufficient number of wastebaskets and other small receptacles for waste and rubbish must be provided where needed and emptied regularly.

7. Approved waste containers must be provided for oily rags and other material requiring special handling.

8. Barrels and similar containers for rubbish must be substantial, approved metal construction, maintained in good condition, have handles and a cover. They must be provided with a two inch air space between the bottom and floor.

STORAGE/STORAGE ROOMS AND AREAS

1. Store all flammable liquids (gasoline, paints, duplicating fluids, cleaners waxes and chemicals) in excess of one day's supply, in proper, locked fire-rated cabinets labeled "Flammables Keep Fire Away." Containers must not exceed 5 gallon capacity, not more than 50 gallons per cabinet and not more than three cabinets per room or fire area.

2. Quantity of flammable liquids in any room is limited to that amount immediately needed for maintenance, demonstration, treatment and laboratory work only, and then no container can exceed (1) one gallon capacity, except that safety containers can be of (2) two gallon capacity.

3. Attics, pipe tunnels, heating plenums, boiler and heater rooms, unused classrooms, mechanical equipment rooms and basements are not designed for storage and such usage is prohibited.

4. All storage rooms must have walls of solid construction, floor to structure above, any louvers in interior doors facing on egress ways must be blocked off with fire rated materials and doors require self closing devices.

5. Maintenance rooms and auto shops cannot be used for overnight garaging of gasoline engine-powered vehicles or equipment, unless so approved by fire marshal.

6. No flammable gas container, such as butane hand torches, welding tanks and oxygen tanks can be stored, in an area subject to excessive heat or possible fire, or adjacent to any flammable liquid.

7. Aerosol cans, compressed gas containers for soda, and any volatile item stored under pressure, flammable or not, must not be stored where subject to excessive heat or fire.

8. In storage, all items must be stored in a neat, orderly manner.

ELECTRICAL

1. Maintain all artificial lighting and replace missing lamps and light covers.
2. Check operation of all emergency lights, daily, wherever located, so they are always ready to function.
3. Properly maintain all exit and exit directional signs so they are always lighted and visible, when building is occupied, both day or night.
4. Use only U. L. approved fuses, extension cords and appliances and replace when frayed or faulty.
5. Do not use extension cords as a substitute for permanent wiring or attach to building surfaces.
6. Do not run extension cords through holes in the walls, ceilings, floors, or through doorways and windows or conceal them behind building walls, ceilings or floors.
7. Extension cords cannot be spliced or be tapped into and do not use multiple plug "octupus" cord arrangements.
8. Light switch covers, plug outlet covers, junction box covers and panel covers must be in place at all times.
9. All outlets, switches, boxes and fixtures must be securely and rigidly affixed to structure.
10. Lighting fixtures, lamp holders, outlets, and appliances cannot have live parts normally exposed.
11. If fuses blow frequently, have electrician check circuit and appliances; do not use higher rated fuse than circuit is designed for.
12. Do not use combustible light shades or affix combustibles to lights.

HOW TO ELIMINATE FIRE HAZARDS IN YOUR BUILDING

1. Using this pamphlet, operation, and maintenance manuals for electrical, plumbing, heating and ventilation equipment, and fire protection and detection equipment, and after discussing local requirements with building administrators and local fire marshal, establish daily, weekly, monthly and quarterly check lists to insure that building is being maintained in a proper manner.

2. Correct, immediately, all items encountered in routine checks that can be corrected by own resources or staff and request in writing of building administrators that items requiring outside services be corrected as soon as possible.

3. Request that school administrators use Connecticut Fire Safety Code and related appendixs, and Connecticut Department of Education, publications on Fire Safety and Prevention in Connecticut schools as guides for maintaining their buildings in a proper manner.

4. Urge persons interested in education to support their fire marshal and school administrators, by allocating funds to make and keep schools fire safe.

NOTE: Section 29-41-2.01(b) of the Connecticut Fire Safety Code states: "Every building or structure shall be so constructed, arranged, equipped maintained and operated as to avoid undue danger to the lives and safety of its occupants from fire, smoke fumes or resulting panic during the period of time, reasonable necessary for the escape from the building or structure in case of fire or other emergency."

It is not the intent of this publication to cover all requirements of the State Fire Safety Code regarding proper housekeeping and maintenance in educational occupancies, but to summarize only and make such requirements known to persons involved with such items.

This publication was compiled by the State Department of Education's Bureau of School Buildings as a guide only, and consultation with the fire marshal in jurisdiction is recommended.

APPENDIX B
IV

ADMINISTRATIVE REGULATIONS

CONNECTICUT STATE DEPARTMENT OF CONSUMER PROTECTION

Model Rocketry Regulations

SECTION 29-106q-1. GENERAL PROVISIONS.

The purposes of these regulations are:

(1) To prohibit the making and launching of dangerous homemade "rocket bombs" and other rocket-like vehicles propelled or intended to be propelled by homemade rocket propulsion devices;

(2) To eliminate the causes of the deaths and tragic injuries to young people that have occurred because of the experiments with explosive or highly energetic "rocket fuels", homemade manufacture of rocket motors and attempted launchings of these homemade rocket devices and

(3) To insure that those commercial devices which are available to the public for educational, scientific, and recreational uses meet certain minimum standards of safety.

SECTION 29-106q-2. DEFINITIONS.

(a) "Rocket" means a device that ascends into air without the use of aerodynamic lifting forces acting against gravity and is propelled by a rocket motor.

(b) "Rocket vehicle" or "vehicle" means the same as the aforementioned "rocket".

(c) "Rocket motor" means a device or combination of devices that provides the necessary force or motive power to cause a rocket to move, said force or motive power being created by the discharge of gas generated by combustion, decomposition, change of state, or other operation of materials contained, carried, or stored solely within said rocket motor and not dependent upon the outside environment for reaction mass.

(d) "Rocket engine" means the same as the aforementioned "rocket motor".

(e) "Thrust augmenter" means a device for increasing the force or motive power of a rocket motor by imparting a portion of the momentum of the rocket motor's exhaust jet to the surrounding environmental medium; and is considered to be a part of a rocket motor when used.

(f) "Model rocket" means a rocket as defined, standardized and limited by these regulations which is not specifically prohibited or exempted by these regulations and whose primary use is for the purposes of education, recreation and competitive sport.

(g) "Solid propellant rocket motor" means a rocket motor containing a fuel and an oxidizer in solid form and deriving its force or thrust from the exothermic combustion thereof.

(h) "Liquid propellant rocket motor" means a rocket motor containing a fuel and an oxidizer in liquid form or in a combined monopropellant form as a single chemical and deriving its force or thrust from the exothermic combustion thereof.

(i) "Hybrid rocket motor" means a rocket motor in which the fuel is in a different physical state--liquid solid, or gaseous--than the oxidizer and deriving its force of thrust from the exothermic combustion thereof.

(j) "Cold propellant rocket motor" means a rocket motor containing a substance which, by change of state, produces the force or thrust of the rocket motor by a process not involving exothermic combustion.

(k) "Steam rocket motor" means a rocket motor that produces its force or thrust by means of steam carried or stored in the rocket motor or rocket vehicle or produced in the rocket motor or vehicle by the heating of water therein.

(l) "Pressurized liquid rocket motor" means a rocket motor that derives its force or thrust by the ejection of a liquid expelled from the rocket motor by pressurized gas.

(m) "Aero model" means a miniature, unmanned replica of a flying device and includes the category "model rocket" as defined herein.

Section 29-106q-3. REQUIREMENTS AND STANDARDS FOR ROCKETS.

Rockets shall comply with the following requirements prior to launch, operation and flight:

(1) Grossweight, including rocket motor and all propellant necessary for operation, shall not exceed 500 grams (1.1 pounds.)

(2) No more than 125 grams (4.4 ounces) of propellant materials shall be contained in the rocket prior to launch, operation and flight.

(3) Construction of rockets shall be of materials having a specific gravity of 1.50 or less, a Brinell Hardness Number of 25 or less

determined with a 2.5 millimeter ball and a 25 kilogram load and an Izod impact strength of 1.0 or less. Polyvinylchloride and polyethylene plastic shall be exempt from the Izod impact strength requirement since they bend and deform rather than shatter. Acceptable materials under this definition include paper, wood and most plastics, Small internal parts may be fabricated from any material provided they are not part of the load-bearing structure of the rocket and would present no hazard to persons or property on the ground in the event of a rocket motor or flight malfunction. Cold propellant rocket motors described in subsection (a) of section 29-106q-r, may be fabricated of aluminum alloy in order to withstand safely the solubility of the cold propellant.

(4) Rockets shall be so designed and constructed as to be capable of repeated flights and shall contain a means for retarding descent to the ground so that the structure shall not be substantially damaged and no hazard shall be created to persons and property on the ground. Recovery devices shall be either forcibly expelled from the rocket or deployed from the rocket by aerodynamic pressure. To minimize hazard in the event of failure of the recovery system or device, the rocket must be so designed that it will upon impact absorb the majority of the impact force by the crushing, deforming, or demolishing of its structure and airframe.

(5) Rocket shall be so designed and constructed to include attached aerodynamic surfaces or other suitable means which will provide stabilizing and restoring forces necessary to maintain a substantially true and predictable flight path.

(6) A rocket shall not contain any type of explosive or pyrotechnic warhead.

SECTION 29-106q-4. REQUIREMENTS FOR ROCKET MOTORS.

(a) Solide propellant rocket motors.

(1) A solid propellant rocket motor shall be produced by a commercial manufacturer and shall have all of the propelling ingredients preloaded into the motor casing in such a manner that they cannot be easily removed. Delay trains and ejection charges may be included as an integral part of the motor or may be preloaded and packaged separately if: (A) The auxiliary package is a single preassembled unit containing all of the remaining combustible material, and (B) the auxiliary package is so designed that an average person would have no difficulty handling and using it safely.

(2) A solid propellant motor casing shall be made of non-metallic material of low thermal conductivity so that the temperature of the external surface of the motor casing shall not exceed 150 degrees Centigrade (302°F) during or after operation.

(3) A solid propellant rocket motor must be so constructed that, should it rupture its casing, the casing shall not fragment.

(4) A solid propellant rocket motor must be so designed and constructed as to be incapable of spontaneous ignition in air, in water, as a result of physical shocks, jarring, impacts or motion under conditions that would reasonable be expected to occur during shipment, storage, and use or when subjected to a temperature of 80 degrees Centigrade (176 degrees Fahrenheit) or less.

(5) A solid propellant rocket motor shall contain no more than 62.5 grams (2.2 ounces) of propellant materials and shall produce less than 80 Newton seconds (17.92 pound-seconds) of total impulse with a thrust duration not less than 0.050 seconds.

(6) A solid propellant rocket motor manufacturer shall subject a random sample of one percent (1%) of each motor production lot to a static test which shall measure and record thrust, duration, thrust--time profile, delay time, and strength of the ejection charge (if any). Solid propellant rocket motor lots must be corrected or destroyed by the manufacturer if:

(A) The total impulse of any test item departs more than twenty percent (20%) from the established mean value for the motor type;

(B) The time delay of the test item departs more than twenty percent (20%) from the established mean value for the motor type; but in no case shall this variation exceed 3 seconds;

(C) The ejection charge (if any) of the test item does not function properly; or

(D) The test item malfunctions in any other manner. Static tests shall be conducted with the test item at ambient temperature.

(7) A solid propellant rocket motor type whose performance deviates from the sample test criteria detailed above within one year from the date of manufacture shall be withdrawn from commercial sale and redesigned to provide reliable operation when ignited within a period of one year from the date of manufacture. All solid propellant rocket motors shall have imprinted upon the exterior of their motor casing the date of manufacture.

(8) A solid propellant rocket motor shall be shipped and stored with no igniter element installed that can be actuated by open flame, at a temperature of less than 150 degrees Centigrade (302 degrees Fahrenheit), or by incident radio frequency or other radiation normally encountered in shipping, storage and use. No manufacturer, distributor, or any other person shall sell, offer to sell, expose for sale, or otherwise make available to the public any type of rocket motor ignition device that is intended to be initiated by a hand-held flame.

(9) A solid propellant rocket motor shall be shipped and sold with complete instruction for its storage, handling and use. These instructions shall contain a warning to read and follow all instructions carefully and to use the rocket motor only in accordance with instruction. In addition, the instructions shall contain the following information:

(A) How to safely ignite the rocket by electrical means;

(B) Performance data on the rocket motor type to include propellant weight, total impulse, average thrust, time delay, and thrust-time curve;

(C) Any special first aid data or steps to be taken in the event of burns or oral ingestion of the propellant;

(D) Proper and safe disposal of the rocket motor if it has become too old, been subjected to conditions that may impair its performance, or, in the opinion of the user, may have become unsafe;

(E) Special action to be taken if fighting any fire in which stored rocket motors may be involved.

(10) A solid propellant rocket motor containing more than 25 grams (0.88 ounces) of propellant material shall be sealed at the factory with a nonflammable, non-metallic seal over the nozzle end and over the forward end, such seals to be readily removable by the user unless the motor is designed to function with the seals in place.

(11) A solid propellant rocket motor in operation shall not expel from its nozzle any pieces of burning propellant and shall be incapable of igniting a piece of dry paper or grass at a distance from its nozzle 500 times the diameter of the nozzle throat.

(b) Cold propellant rocket motors.

(1) A cold propellant rocket motor shall be sold as a completely prefabricated, assembled device ready for attachment to a rocket vehicle and ready for the user to fill with cold propellant material; the motor must be so designed that it cannot easily be modified to operate under higher pressures than those for which it was designed and manufactured.

(2) A cold propellant rocket motor shall use as propellant only dichlorodifluormethane (Freon-12), dichlorofluoromethane (Freon-21) dichlorotetrafluoroethane (Freon-114) or a combination thereof. This cold propellant material shall be shipped, stored, sold and made available separately from the rocket motor and shall be transferred to the rocket motor only after the motor and the rocket vehicle to be propelled by the motor is on a launching device and otherwise ready for operation and flight.

(3) A cold propellant rocket motor shall be so designed for a working internal pressure no greater than 7 atmospheres gauge (103 pounds per square inch) and shall be equipped with a non-adjustable, non-removable safety valve or pressure release means that will operate when the internal pressure inside the cold propellant rocket motor casing exceeds 10 atmospheres gauge (147 pounds per square inch). The cold propellant rocket motor casing shall be so designed and constructed that it possesses a minimum burst pressure of 20 atmospheres gauge (294 pounds per square inch).

(4) A cold propellant rocket motor must not be heated to a temperature in excess of 35 degrees Centigrade (102 degrees Fahrenheit) prior to launch, operating or test.

(5) Materials used in the construction of a cold propellant rocket motor must comply with the material requirements detailed in subsection (3) of section 29-106q-3. If the cold propellant rocket motor is an integral, nonremovable part of the rocket air frame, it must also comply with the requirements of subsection (4) of section 29-106q-3.

(c) Pressurized liquid rocket motors.

(1) A pressurized liquid rocket motor shall be sold as a completely prefabricated, assembled device ready for the user to fill, pressurize and use; the motor must be so designed that it can not be modified easily to operate under higher internal pressures than those for which it was designed and manufactured.

(2) A pressurized liquid rocket motor shall use as a propellant or reaction mass water in the liquid state or a nontoxic liquid.

(3) A pressurized liquid rocket motor shall be designed for an internal working pressure no greater than 7 atmospheres gauge (103 pounds per square inch) and shall be equipped with a nonadjustable, non-removable safety valve or pressure release means that will operate when the internal pressure of the rocket motor exceeds 10 atmospheres gauge (147 pounds per square inch). The pressurized liquid rocket motor casing shall be so desinged and constructed that it possesses a minimum burst pressure of 20 atmospheres gauge (294 pounds per square inch).

(4) A pressurized liquid rocket motor must be shipped and stored with no propellant material inside it and vented to atmospheric pressure.

(5) The pressure used by the pressurized liquid rocket motor must be either (A) generated or produced by a pressure source such as a pump outside the rocket motor and rocket vehicle powered thereby, or (B) generated by the non-combustible chemical reaction of chemicals within the rocket motor or rocket vehicle propelled thereby.

(6) Materials used in the construction of a pressurized liquid rocket motor must comply with the material requirements detailed in subsection (3) of section 29-106q-3. If the pressurized liquid rocket motor is an integral, nonremovable part of the rocket airframe, it must also comply with the requirements of subsection (4) of section 29-106q-3.

SECTION 29-106q-5. AUTHORIZED LOCATIONS FOR OPERATION.

A rocket may be launched, operated or flown only in a location approved by the authority having jurisdiction and only upon compliance with the following conditions:

(1) There shall be a ground area whose shortest dimensions is not less than one-fourth (1/4) the anticipated maximum altitude of the rocket(s) to be flown.

(2) The location shall be one where rocket flights will not create a hazard to persons and property in the immediate vicinity.

(3) The location shall not contain or be adjacent to high-voltage power lines, major highways, multi-story buildings, or other similar obstacles.

(4) The launching point shall be not closer than 25 feet to the boundaries of the location.

SECTION 29-106q-6. LAUNCHING. Rockets may be launched upon compliance with the following conditions:

(1) A device or mechanism shall be used which provides a suitable deflector to prevent the exhaust jet from impinging directly on the ground or launch surface and shall restrict the horizontal motion of the model until sufficent flight stability shall have been obtained for a reasonable safe, predictable flight.

(2) Launching or ignition shall be conducted by remote electrical means fully under the control of the person launching the model; however, rockets propelled by pressurized liquid rocket motors may be launched using a mechanical release mechanism.

(3) A launching angle of more than 60 degrees from the norizontal shall be used.

(4) At least one adult person competent, in the opinion of the authority having jurisdiction, to supervise the safe operation of rockets shall inspect each rocket before flight and shall supervise the safe operation of rockets, shall inspect each rocket before flight and shall supervise the launching of each rocket.

(5) A 5-second countdown shall be given prior to each launch to notify all persons in the immediate vicinity that a launching is imminent.

(6) Surface winds at the launch site shall be less than 20 miles per hour and visibility shall be greater than 2000 feet.

(7) A rocket shall not be launched so as to create a hazard to aircraft or in violation of Section 307, 72 Statute 749, 49 United States Code 1348, "Airspace Control and Facilities"; Federal Aviation Act of 1958 covering Federal Aviation Regulations Part 101, sub-part A, pp. 101-1, a-3, a through d, or later revisions of amendment thereto.

(8) Rockets may be launched only during daylight hours except for valid educational scientific experiments.

(9) All materials such as recovery system wadding or igniter holding devices which are subject to high temperatures and ejected from the rocket during the launch and recovery sequence shall be of a sufficiently flame-resistant nature so as to prevent any ignition upon landing.

(10) All persons conducting, assisting, or observing the launching shall remain at least 10 feet from rockets containing less than 25 grams of propellant or having less than 20 Newtown seconds (4.5 pound/seconds) total impulse and at least 20 feet from rockets exceeding these limits during the countdown and launching sequence.

SECTION 29-106q-7. TESTS AND EXPERIMENTS

Rocket motors may be tested or operated on the ground for the purpose of determining performance or may be used as the motive power of an experiment conducted on the ground under the following conditions:

(1) The rocket motor shall be affixed to the testing device or to the experimental mechanism in such a manner that said motor shall not become free during the conduct of the test or experiment.

(2) The rocket motor shall be ignited only by remotely operated electrical means fully under the control of the person conducting the test or experiment; however, starting of a pressurized liquid rocket motor may be carried out remotely by means of a lanyard or other mechanical device.

(3) When tests or experiments are conducted indoors, the exhaust from the rocket motor thus tested or thus providing the motive power shall be directed into a nonflammable hood or vent which shall lead directly to the outside of the building; however, because of the ambient temperature non-toxic nature of the exhaust jet from cold propellant rocket motors and pressurized liquid rocket motors, these rocket motor types are exempted from this requirement.

(4) Before a rocket motor may be tested experimentally or used on the ground, its exhaust path shall be cleared of all flammable objects prior to igniting or starting such motor; however, cold propellant rocket motors and pressurized liquid rocket motors are exempted from this requirement.

(5) Persons who conduct, participate in or observe static tests or ground operation of a rocket motor shall stand a distance no less than 5 feet away from such motor and never within a 30 degree angle of a direct line with the motor's longitudinal axis during the conduct of the test or operation.

(6) Static tests and other ground experiments shall be conducted with the rocket motor at a temperature of less than 80 degrees Centigrade (176 degrees Fahrenheit).

(7) An adult person competent, in the opinion of the authority having jurisdiction, to supervise the safe operation of rocket-powered ground tests and experiments shall inspect each testing device or experiment before the test or experiment may be conducted and shall supervise the conduct of said test or experiment.

SECTION 29-106q-8. TESTING AND CERTIFICATION.

(a) Rockets, rocket motors, rocket equipment, and other rocket products offered for sale, exposed for sale, sold, or otherwise made available to the public of this state shall be examined and tested by the Commissioner of Consumer Protection to determine whether or not they comply with the standards and requirements detailed in sections 29-106q-3, 29-106q-4, and 29-106q-6 hereof, and shall certify as acceptable under the provisions of these regulations those products that do comply. At the discretion of the Commissioner of Consumer Protection, such examination, testing, and certification may be carried out by an independent non-profit organization such as the National Association of Rocketry or its successor organization affiliated with the National Aeronautical Club of the United States having jurisdiction over the sporting aspects of rocketry as the United States representative to the Federation Aeronautique Internationale.

(b) The Commissioner Consumer Protection shall maintain a current and complete list of all those rockets, rocket motors, and other rocket devices which are certified as complying with sections 29-106q-3, 29-106q-4, and 29-106q-6 hereof and shall make available to citizens of this state and to public safety officials requesting same copies of this list.

SECTION 29-106q-9. PROHIBITED ACTIVITIES. The following activities are prohibited:

(1) The use of rockets for pyrotechnic purposes and for the primary purpose of producing a spectacular display of color, sound, light, or any combination thereof.

(2). The use of a rocket as a weapon against targets.

(3) The use of a rocket motor contrary to the instructions for its use and contrary to the provisions of sections 29-106q-3 to 29-106q-9, inclusive.

(4) Tampering with a rocket motor in any manner or degree which is contrary to the purpose for which said motor is designed and intended to be used; or contrary to the provisions of sections 29-106q-3 to 29-106q-10, inclusive.

(5) The sale, offering for sale, exposing for sale, or otherwise making available to the public any rocket or rocket motor that does not comply with the requirements of sections 29-106q-3 and 29-106q-4 hereof.

(6) The launching, attempted launching, operating, discharging, flying or otherwise activating a rocket or rocket motor without first having complied with the provisions of sections 29-106q-3 to 29-106q-9, inclusive.

(7) The manufacture, production, fabrication, making, operating, maintenance, launch, flight, test, activation, or discharge of an experimentation with rockets not complying with the requirements of section 29-106q-3, solid propellant rocket motors not complying with the requirements of section 29-106q-4, liquid propellant rocket motors, hybrid rocket motors, steam rocket motors, cold propellant rocket motors not complying with the requirements of section 29-106q-4, pressurized liquid rocket motors not complying with the requirements of section 29-106q-4, rocket propellant chemicals for solid, liquid and hybrid rocket motors, including monopropellants, and other rocket types and rocket motor types not specifically covered by or exempted by these regulations.

(8) The use of fuse, wick or other ignition devices intended to be activated by an open flame for the purpose of igniting or starting a rocket motor.

(9) Affixing to any rocket or rocket motor a statement of compliance with these regulations in the absence of certification required by section 29-106q-8.

(10) Reloading any solid propellant rocket motor with any material once said motor has been operated.

(11) Reloading or refilling any cold propellant rocket motor with any material not specifically recommended or made available by the manufacturer.

SECTION 29-106q-10. EXCEPTED ACTIVITIES.

(a) The provisions of sections 29-106q-3 to 29-106q-10, inclusive, shall not apply to the design, construction, production, fabrication, manufacture, maintenance, launching, flight, test, operation, use of, or any activity in connection with a rocket or rocket motor when carried on by or engaged in by (1) the government of the United States, (2) any state government, (3) a college, university, or other institution of higher learning, or (4) any individual, firm, partnership, joint venture, corporation, or other business entity engaged in research, development, production, test, maintenance, or supply of rockets, rocket motors, rocket propellants, or rocket components as a business under contract to or for the purposes of sale to any government, college, university, institution of higher learning, or similarly engaged business entity.

(b) The provisions of sections 29-106q-2 to 29-106q-4, inclusive, shall not apply to the design, construction, production, fabrication, manufacture, maintenace, launching, flight, test, operating, use of, or any activity in connection with rocket propelled model aircraft which sustain themselves against gravity by aerodynamic lifting surfaces during the entire duration of their flight in the air, or to the rocket motors that provide propulsion therefor.

(c) The provisions of sections 29-106q-5, 29-106q-6 and 29-106q-7 shall not apply to model rockets propelled by pressurized liquid rocket motors containing less than 250 milliliters (8.45 liquid ounces) of water.

APPENDIX B
V-1

REGULATIONS CONCERNING EYE PROTECTIVE DEVICES AS AUTHORIZED BY SECTION 214a OF THE CONNECTICUT GENERAL STATUTES

The regulations of Connecticut state agencies are amended by adding sections 10-214a - 1 to 10-214a - 3, inclusive as follows:

Section 10-214a - 1. By whom, when and where eye protective devices shall be worn: definitions. Any person who is working, teaching, observing, supervising, assisting in or engaging in any work, activity or study in a public or private elementary or secondary school laboratory or workshop where the process used tends to damage the eyes or where protective devices can reduce the risk of injury to the eyes concomitant with such activity shall wear an eye protective device of industrial quality in the manner in which such device was intended to be worn. For the purposes of sections 10-214a - 1 to 10-214a - 3, inclusive, "workshop" and "laboratory" shall include any room or area used to teach or practice industrial arts, vocational and technical education, science, arts and crafts, or any similar skill, activity or subject. The following list of sources of danger to the eyes and the type of protection required to be worn in each case is exemplary, not exclusive:

SOURCE OF DANGER TO THE EYES	TYPE OF PROTECTION REQUIRED
(a) Caustic or explosive chemicals	Clear goggles, splash proof
(b) Explosives, solids or gases	Clear goggles
(c) Dust producing operations	Clear goggles, splash proof
(d) Electric arc welding	Welding helmet
(e) Oxy-acetylene welding	Colored goggles or welding helmet
(f) Hot liquids and gases	Clear goggles, splash proof
(g) Hot solids	Clear or colored goggles, or spectacles
(h) Molten metals	Clear or colored goggles
(i) Heat treatment or tempering of metals	Clear or colored goggles
(j) Glare operations	Colored spectacles or goggles, or welding helmet
(k) Shaping of solid materials; Chipping, cutting,grinding, milling, sawing, stamping	Clear goggles or spectacles
(l) Repairing or servicing of vehicles when hazard is foreseeable	Clear goggles or spectacles
(m) Spraying and dusting	Clear goggles, splash proof
(n) Other similar activity being conducted in the instructional program which risks damage to the eyes	Proper eye protective device

Section 10-214a - 2. Minimum standards for the design, construction and quality of eye protective devices used in schools.

Any eye protective device used in such school workshops or laboratories shall be designed and constructed to resist impact, provide protection against the particular hazard for which it is intended, fit snugly without interfering with the movements of the user and be durable, cleanable, and capable of frequent disinfection by the method prescribed for such device by the school medical adviser.

All materials used in such eye protective shall be mechanically strong and lightweight, non-irritating to perspiring skin and capable of withstanding washing in detergents and warm water, rinsing to remove all traces of detergent and disinfection by methods prescribed by the school medical adviser without visible deterioration or discoloration. Metals used in such devices shall be inherently corrosion resistant. Plastics so used shall be non-flammable and shall not absorb more than five per cent of their weight in water.

Section 10-214a-3. Responsibilities of public and private elementary and secondary school governing bodies. The governing board or body of each public and private elementary and secondary school in the state shall require the use of appropriate eye protective devices in each laboratory and workshop by any person in such areas during any activity engaged in, and shall post warnings and instructions in laboratories and workshops which include the list of hazards and protection required set forth in section 10-214a - 1. Such boards shall make and enforce rules for the maintenance of all eye protective devices in clean, safe condition and shall replace any such protector which becomes irritating to the skin.
Purpose: To direct the school administrators in the kinds, construction, times and uses of devices for eye protection of teachers and pupils in school laboratories and workshops.

Connecticut Law Journal-
January 9, 1968

APPENDIX B
V-2

Connecticut State Board of Education
Hartford

February 14, 1968

Series: 1967-68
Circular Letter No. C-13

To: Chairmen, Boards of Education
Heads of Science Departments
Superintendents of Schools

From: William J. Sanders

Subject: Policy Statement re: "Treatment of Animals used for Instruction in the Schools"

The State Board of Education, in regular session on February 7, 1968, adopted the following policy statement:

> "For science to be taught effectively in the schools, there must be a variety of objects, equipment, materials and supplies available for the study at first hand. Living plants and animals are included, since they comprise a significant part of man's environment.
>
> "It is the position of the State Board of Education that the use of living animals as an adjunct to teaching science is quite appropriate and is to be encouraged under conditions which insure proper care and treatment for any creatures used for instructional purposes. This is in keeping with the requirement of Connecticut Statutes that schools shall provide 'instruction in the humane treatment and protection of animals.'
>
> "The State Board of Education urges that the following principles be observed in carrying on the instructional program of the public elementary and secondary schools and in any other school-sponsored activities:
>
> 1. Animals should always be maintained under the best possible conditions of health, comfort and well being.
> 2. No vertebrate animal should be subjected to any experiment or procedure which interferes with its normal health or causes it pain or distress.

3. Any experiment which involves the use of vertebrate animals should be carried out by or under the personal direction of a person trained and experienced in approved techniques for such experiments."

APPENDIX B
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CONNECTICUT STATE DEPARTMENT OF EDUCATION
Bureau of Elementary and Secondary Education
Hartford

To: Science Department Chairmen
Science Supervisors
Professors of Science Education

From: Sigmund Abeles, Consultant in Science Education

Subject: Alcohol Lamps

Over the past few years there has been a rapid increase in the use of alcohol lamps in science classrooms. This relatively inexpensive source of heat has considerable use with a number of the new elementary, middle and junior high school science courses.

In general, the lamps are relatively safe to operate. Statistically, the ratio of the number of accidents to the number of times the lamps are used is very small. This is small comfort however if the accident occurs in one of your classrooms. In the last two years several accidents involving the use of alcohol lamps have come to my attention. In each instance the accident was caused when the student came to the teacher's desk or bench area for a 'refill.'

The results of the above situation varied somewhat. The following sequence of events however bears some similarity to what can happen. A student comes to the teacher's desk (or lab table) to replenish the alcohol in his empty lamp. A storage can with fluid is either uncovered or loosely covered on the desk. The teacher (or student) attempts the refill. Fumes from the can are ignited by an unseen ember on the lamp. Flames are spewed over the surrounding area. Secondary effects can include ignition of hair, clothing etc. Therefore, would you please convey the following information to teachers and student teachers who have occasion to work with alcohol lamps.

It is strongly recommended that no alcohol storage receptacles be situated in a classroom. If alcohol lamps are to be used in a class, additional capped replacement lamps should be prepared before the class and kept out the way, preferably in the storeroom until their use is required. The number of these replacement lamps should be kept to a minimum. The new lamp should be given to the student by the teacher. Exhausted alcohol lamps should not be refilled during a class.

APPENDIX B
V-4

Connecticut State Department of Education
Bureau of Elementary and Secondary Education
Hartford

To: Science Department Chairmen and Science Supervisors

From: Sigmund Abeles, Science Consultant

Subject: Lasers

The past few years have seen the introduction of lasers into a number of junior and senior high school classrooms and laboratories. These devices serve a number of interesting laboratory and demonstration purposes ranging from ray optics to the calculation of the laser beam wavelength. They have invariably proven to be "crowd pleasers" because of their relative newness, frequent appearences in the news, etc. A few words of caution are necessary in connection with their use however.

A set of standards was adopted to serve as interim guidelines for the safe use of lasers by the Second International Laser Safety Conference in March 1969. These standards were stated as follows:

Permissible Intensity on the Skin

Pulsed Laser	0.1 joule/cm^2/pulse
Continuous Wave Laser	1.0 watt/cm^2

Permissible Irradiation at the Cornea for 6943Å *

	Q-Switched Pulse (Joules/cm^2)	Non Q-Switched Pulse (Joules/cm^2)	Continuous Wave (Watts/cm^2)
3mm pupil diameter	5.0×10^{-8}	5.0×10^{-7}	5.0×10^{-6}
7mm pupil diameter	1.0×10^{-8}	1.0×10^{-7}	1.0×10^{-6}

*6943Å is the wavelength of the beam from ruby lasers.

The lasers most often acquired by schools are of the HeNe continuous wave variety.

The wavelength of these lasers is 6328Å. While this is not exactly the same wavelength as that mentioned in the above chart, it is probably close enough to make use of the same guidelines until more information becomes available.

Please note that the suggested maximum permissable irradiation of the cornea from a continuous wave laser is 1.0×10^{-6} watts/cm^2. The output of the HeNe lasers is often at the 1.0×10^{-3} watt level with a beam diameter of 2 to 3 mm. This output is considerably in excess of the minimum recommendations put forth by the Second International Laser Safety Conference.

Therefore, it is recommended that until further data become available, the following precautions as outlined by the American Conference of Governmental Industrial Hygienists be adhered to.

General Precautions

(1) Personnel should not look into the primary beam or at specular reflections of the beam when power or energy densities exceed the permissible exposure levels.

(2) Avoid aiming the laser with the eye to prevent looking along the axis of the beam, which increases the hazard from reflections.

(3) Work with lasers should be done in areas of high general illumination to keep pupils constricted and thus limit the energy which might inadvertently enter the eyes.

(4) Shatter resistant safety eyewear designed to filter out the specific frequencies characteristic of the system affords partial protection. Safety galsses should be evaluated periodically to insure maintenance of adequate optical density at the desired laser wavelength. There should be assurance that laser goggles designed for protection from specific lasers are not mistakenly used with different wavelengths of laser radiation. Distinctively colored frames are recommended and optical density should be shown on the filter. Laser safety glasses exposed to very intense energy or power levels may lose effectiveness and should be discarded.

(5) The laser beam should be terminated by a target material that is nonreflective and is fire resistant. An area should be cleared of personnel for a reasonable distance on all sides of the anticipated path of the beam.

(6) Avoid electrical shock from the potentially dangerous electrical sources of high and low voltage.

(7) Special precautions should be taken if high voltage tube rectifiers (over 15KV) are used because there is a possibility that x-rays will be generated.

Specific Precautions for low powered continuous wave gas lasers

(1) General precautions with reference to aiming and the avoidance of specular reflection should be observed.

(2) The laser beam should be terminated at the end of its useful beam path by a material that is a diffuse matte of such color or reflectivity to make positioning possible but should minimize the reflection.

(3) Reflective material should be elminated from the beam area, and good housekeeping should be maintained.

APPENDIX B
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Connecticut State Department of Education
Bureau of Secondary and Elementary Education
Hartford

To: School Superintendents
Elementary and Secondary School Principals
Vocational Technical School Directors
Science Department Chairmen and Teachers

From: Sigmund Abeles, Science Consultant

Subject: Potential Risk of Excessive Exposure to X-rays During Use of Certain Cold Cathode Discharge Tubes

Recent studies by the United States Public Health Service have demonstrated that certain types of cold cathode gas discharge tubes may produce x-rays in sufficient amounts to be hazardous to students and instructors, e. g., Crookes tubes, often used with Tesla or induction coils for demonstrating heat, magnetic or fluorescent effects. (This does not apply to oscilloscope tubes)

The United States Public Health Service has requested that teachers refrain from using these devices until the State Health Department has determined whether x-rays are emitted, and when they are, whether they are emitted in sufficient amounts to constitute a hazard.

Requests for evaluation of cold cathode discharge tubes should be addressed to the:

Occupational Health Section
Connecticut State Department of Health
79 Elm Street
Hartford, Connecticut 06115
Telephone Number: 566-5668

A representative of the Occupational Health Section, Connecticut State Department of Health, will visit schools reporting the possission of such devices as soon as possible to determine whether these are safe for use.

APPENDIX B
V-6

Connecticut State Department of Education
Bureau of Elementary and Secondary Education
Hartford

To: Science Department Chairman
Science Supervisors
Professors of Science Education

From: Sigmund Abeles, Consultant in Science Education

Subject: CENCO Beta Ray Capsule No. 71022 (PG 0395)

The Central Scientific Company of Chicago, Illinois has informed us that the Department of Health, Education and Welfare, Public Health Service, Food and Drug Administration, considers that a product formerly distributed by Central Scientific Company, may represent a public health hazard.

The product involved is Central Scientific Company Catalog Number 71022, Beta Ray Capsule in the form sold from November 11, 1948 to September 10, 1963. In this form it consisted of a sealed Radium D source which provided a beta ray activity of 15 to 20 milliroentgens per hour at a distance of 3 inches from an ionization detection meter. This unit was sealed in a gelatin capsule of approximately 13 mm length by 5mm diameter. Its appearance is similar to those used for dispensing pharmaceuticals. The radioactive material appears to be absorbed upon a fibrous material within the capsule shell. A variety of capsule colors were distributed e. g. orange and white, all blue, etc.

It is requested that you determine if your school or organization has any such beta ray capsules. Units of this type should be disposed of as radioactive material to a licensed disposal contractor or returned for a credit of $11.00 to:

Central Scientific Company   Attn: Mr. Victor R. Stonevic
2600 South Kostner Avenue   Radiation Safety Officer
Chicago, Illinois 60623

Packaging, Monitoring, and Mailing

If you intend to send it back to CENCO, packaging, monitoring, and mailing should be accomplished with the aid of:

Mr. Arthur Heubner
Acting Assistant Director of Compliance (Radiation)
Department of Environmental Protection
State Office Building
Hartford, Connecticut 06115
Pone 566-5668

Please contact him if you have one or more of the CENCO No. 71022 capsules.

Mr. Heubner will come to your school and perform the following services:

a) check the capsule to make sure it's the right one
b) advise on the packing of the capsule
c) check the radiation at the surface of the package to make sure it's within the required limits
d) supply you with the appropriate "radioactive" labels
e) help you fill out the labels.

The packing instructions supplied by CENCO appear in the following paragraph. Please have the materials on hand when Mr. Heubner arrives, but do not pack the capsule until he gets to your school.

"The beta ray capsule should be wrapped in tissue paper and placed in a small box and then further wrapped with tissue paper and placed in the center of a box no smaller than 4 inches on a side. Two "Radioactive White I" labels should be affixed to opposite sides of the outer box. The dose rate at any point on the external surface of the outer shipping container should not exceed 0.5 millirem per hour. This box then should be shipped back to us by common carrier or REA freight. Do not ship back by regular mail.

If you have some thin lead or thin aluminum available, wrap the beta ray capsule first with the metal before packing in the inner box. It takes only about 0.145 inches of aluminum to reduce the leakage of radiation by 100%."

CENCO has indicated to me that approximately 3500 capsules were sold on a nationwide basis from November 11, 1948 to September 10, 1963. These went to schools, colleges and industries. The chances of your having a capsule therefore, may not be great. You should check, however, to see if you have one or more on hand and contact Mr. Heubner should such be the case.

APPENDIX C

SELECTED BIBLIOGRAPHY

APPENDIX C

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